ELECTRO-MEDICAL INSTRUMENTS

BY

K. SCHALL

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Electro-Medical Instruments And their Management,

AND

ILLUSTRATED PRICE LIST OF ELECTRO-MEDICAL APPARATUS,

BY

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CONTENTS OF "ELECTRO-MEDICAL INSTRUMENTS AND THEIR MANAGEMENT."

PREFACE.

The following pages explain as simply as possible the physical laws which are of importance in using Electricity for Medical and Surgical purposes. They describe the necessary apparatus and their construction; they give a few practical hints about the apparatus best suited under special circumstances; they show how faults may be avoided, or, at any rate, how they may be detected and rectified.

Should the reader, who lacks time to study larger works on Electricity, find the following pages a help in making his electrical instruments familiar to him, thus facilitating their management, this little pamphlet will not have been written in vain.

1892. K. SCHALL.

The pamphlet, "Electro-Medical Instruments and their Management," was published for the first time about seven years ago. Since that time many Medical Men assured me that it has been a help to them, and this encouraged me not only to republish, but also to enlarge it considerably, hoping that the new chapters may be found useful too.

May, 1899. K. SCHALL.

ELECTRO-MEDICAL INSTRUMENTS AND THEIR MANAGEMENT.

ELECTRICITY is the result of some kind of motion, like heat, light, magnetism, etc.; it is closely related to these forces and can be easily converted into them.

We possess many means and ways of producing it, such as friction, chemical action, induction, mechanical power, etc. All these methods are used in applying electricity for medical purposes, but before explaining them one by one, it will be necessary to define a few general expressions.

Positive and Negative.—If we rub a glass bar, or a stick of sealing-wax, with a dry cloth or fur, and apply the knuckle to the rubbed place, a small spark appears. The friction has electrified the sticks, and the consequence thereof is that they attract light things, such as pieces of paper, electrify these as well, but repel them immediately after having touched them. A glass bar repels a piece of paper after having electrified it, but a stick of sealing-wax, after having been rubbed, attracts the same paper very strongly. This shows that the electricity in the glass bar is not the same as the electricity in the stick of wax; that is to say, there are two kinds of electricity. It is the custom to call the kind of electricity produced through rubbing a glass bar *positive* electricity, and the electricity produced by rubbing a stick of wax or india-rubber, *negative* electricity. The above experiment shows that two bodies charged with the same kind of electricity repel each other, and that bodies charged with different kinds of electricity attract each other.

Normal Condition.—It is a mistake to imagine that the friction has charmed some new strange power into the sticks. It will be more correct to suppose, that in their normal (that is to say unrubbed) condition, the sticks contained negative and positive electricity in equal quantities, and as long as this was the case we could not discern the presence of the power at all. The friction, however, disturbed the normal condition by separating the two kinds of electricity contained in those bodies, and under these conditions only can we detect the presence of electricity.

Conductors and Insulators.—The separated kinds of electricity can be united again by means of a conductor. After rubbing a glass bar, or a stick of wax, we find that it has become electrified in the rubbed places only, and remains non-electric where it was not rubbed. Obviously

therefore electricity cannot spread equally over glass or wax, but remains localised. Substances which do not conduct electricity, such as glass, silk, ivory, oil, pure water, air, paraffin-wax, etc., are called non-conductors or insulators. Other substances, which allow electricity to pass freely, such as all metals, carbon, some minerals, etc., are called conductors. Between conductors and non-conductors there is, however, a third class of materials, which do not conduct electricity nearly as well, as, for instance, metals do, but which still conduct it decidedly to a certain extent; such as acids, salt and alkali solutions, etc. Such fluids are called half-conductors. Now to this class belongs the human body.

It is of the greatest importance and convenience that there are bodies which conduct, and others which do not conduct electricity, for we are thus enabled to direct the electricity exactly to the spot where we desire its action, and to send it along metal wires which are supported by insulators, over any distance we like.

By rubbing a glass stick, we have separated the positive and the negative electricity contained in the stick: the positive electricity remained in the glass bar; the negative passed through the rubbing cloth and the body of the rubbing person into the earth. In rubbing a metal stick we separate the two kinds of electricity in the same way; but we can prove this only by insulating one end of the metal stick, for instance, by cementing it into a glass tube, and holding the glass tube in our hand while rubbing the metal. If we were to touch the non-insulated metal stick, the separated negative and positive electricity would get re-united again immediately through the body of the rubbing person, and would leave no trace at all.

For a long time friction was the only means known to electrify bodies; but about a hundred years ago, Volta and Galvani discovered another and far more convenient method to produce electricity, *i.e.*, the simple contact of two different metals, and chemical action. They thereby gave the first impulse to the wonderful development of electricity which we have witnessed in our day. The electricity produced in this way has been called galvanic electricity, in honour of one of its discoverers.

GALVANIC ELECTRICITY.

Electro-motive Force.—If we immerse a piece of metal in some fluid which has the power of acting chemically on the metal, the two kinds of electricity are separated too. The power which disturbs the normal condition, and separates the positive from the negative electricity, is called *electro-motive force.* The E.M.F. is in some proportion to the intensity of the chemical action, but is *independent of the size or shape of the metal.*

If we immerse zinc in diluted sulphuric acid, the zinc becomes negatively, the sulphuric acid a little positively electric. Copper im-

mersed in sulphuric acid becomes negatively electric, but not so strongly as zinc. Platinum immersed in sulphuric acid gets positively electric, and the acid becomes negative. This shows that different metals react differently with one and the same liquid, and they can be classified in such an order that, in contact with a liquid, always the preceding metal gets negative compared with those that follow. This order changes slightly with various liquids, but not very much. In diluted sulphuric acid, for instance, the most important metals follow one another as follows: Zinc, iron, lead, nickel, bismuth, copper, silver, platinum, carbon.

By immersing at the same time two different metals, the one of which gets negatively, and the other positively electric, in the exciting liquid, we increase the tension, for in this case we have two E.M.F.'s instead of one. On the exciting liquid much depends too; zinc and carbon, for instance, have twice as high an E.M.F. if dipped in chromic acid than when dipped in sulphuric acid only. Such an arrangement, *i.e.*, two metals, or a carbon and a metal in an exciting fluid, is called a galvanic element or cell. Some special kinds of cells will be mentioned later on. The following list shows the different metals and exciting liquids of which the cells mostly used in medical electricity are composed, as well as their respective E.M.F.'s.

If the E.M.F. of a Daniell cell, *i.e.*, zinc in diluted sulphuric acid, and copper in saturated solution of sulphate of copper, is equal to 1, the following combinations would be equal to:—

Chloride of silver, diluted chloride of ammonium, or chloride of zinc solution, zinc (De la Rue's cell)	1·0
Manganese and carbon, saturated chloride of ammonium solution, zinc (Leclanché cell)	1·48
Carbon, bichromate of potassium, diluted sulphuric acid, zinc (Grenet cell)	1·8
The same element with bisulphate of mercury instead of bichromate	2·0

Arrangement of Cells.—The above list shows that no single cell possesses an E.M.F. higher than two units, if we take that of the Daniell cell as one unit. For reasons, however, which we shall explain later on, a much larger E.M.F. is often needed, and we can obtain it by connecting several cells, so that the zinc of the first cell is connected with the carbon of the second, the zinc of the second with the carbon of the third, etc. In this way we add the E.M.F.'s. of the single cells together, and if, for instance, forty Leclanché cells are connected like this, the E.M.F. between the two end poles (*i.e.*, the first carbon and the fortieth zinc), will be forty times as high as that of a single Leclanché cell. To connect the cells in this manner is called connection "in series;" it is the most frequently used method of connecting cells. There are, however, other ways of connecting elements, but as these are of importance for cautery only, we shall explain them under cautery.

Current.—As soon as the two metals are connected by a conductor or half-conductor, the two separated kinds of electricity are able to reunite again. While discharging, the electricity accumulated at the poles gets less, but it is replaced immediately by the E.M.F., so that the discharge goes on as long as the electrifying cause (in this case the chemical action) exists, or till the circuit gets broken. There exists, then, in the circuit a *continuous current*, which is generally supposed to start from the positive pole, and to pass through the conductor to the negative pole, and inside the cell from the negative metal through the exciting liquid to the positive metal, thereby forming a complete circuit.

The larger a cell and its store of chemicals is, the longer will it be able therefore to maintain a current, and the constancy of an element, *i.e.*, the length of time for which an even strength of current can be got out of it, is in direct proportion to its size.

If we call the metal *positive* from which the current starts into the conductor, the copper, for instance, is *positive* as far as it projects above the liquid, but is *negative* as far as it is covered by the liquid, and *vice versa* with the zinc.

Resistance.—The free passage of the current depends on the nature of the conductor through which the current has to pass. We have already mentioned that the conducting capacity of various bodies varies widely. Metals are the best conductors, but even they differ much. For instance, one yard of copper wire allows ten times as much electricity to pass as one yard of German silver wire under otherwise equal conditions. It would be more correct to say that German silver has ten times the resistance of copper. The following table shows the resistance of some materials; wires of one metre length and one millimetre sectional area have the following resistance:—

Copper	0·056	Units
Iron	0·24	"
Platinum	0·35	"
German silver	0·47	"
Carbon, as used for incandescent lamps	76·0	"
Salt water	95000·0	"
Diluted sulphuric acid, 1 to 11	280000·0	"
Distilled water	10000000·0	"

The resistance of a body depends on its length and diameter. The resistance increases with the length, ten yards of wire having twice as much resistance as five yards of the same wire. If, however, the diameter of the conductor increases, the resistance decreases accordingly. The resistance of the human body, for instance, is ten times less if we apply electrodes ten inches square than if we apply electrodes one inch square only.

Up to now we have only mentioned the external resistance, that is, the resistance which the current has to overcome outside the element. The current meets, however, some resistance inside the cell, and this is called internal resistance. The internal resistance depends on the

conducting capacity of the exciting liquid, and, moreover, if the size of the metal plates gets increased, the resistance gets diminished accordingly, and *vice versa.* If the external resistance is great, 500 or more ohms, the internal resistance of the battery can be practically neglected; if the external resistance is, however, as small as, for instance, in a cautery burner, the internal resistance is of great importance. Some examples will follow later on.

Polarisation.—There is another obstacle to the rapid discharge of electricity. The electric current decomposes the fluids through which it is passing; for instance it decomposes water into hydrogen and oxygen. As soon as the metals of a cell are connected by a conductor, or to express it shorter, as soon as the current is closed, bubbles of oxygen gas appear on the negative, and bubbles of hydrogen gas on the positive metal.

The quantity of the produced gas is exactly in proportion to the strength of current. In a cell consisting, for instance, of zinc, sal-ammoniac and silver, the silver gets covered with gas bubbles very shortly after the circuit is closed, and then the cell consists only of zinc and hydrogen, which has a very much lower E.M.F. than zinc and silver. The strength of current decreases very considerably in consequence of this formation of gas, and therefore the first consideration in constructing a cell is to prevent this action, which is called *polarisation.*

Depolarisation.—It can be achieved in different ways: either by shaking the metals, or blowing air into the fluid, in order to get rid of the bubbles mechanically by simply shaking them off, or by chemical action. The positive metal is then surrounded with materials containing plenty of oxygen, which unites eagerly with the hydrogen and becomes water, annihilating thus the gas bubbles. For this reason the Bunsen or Grove cell contains nitric acid, the Grenet cell chromic acid, the Leclanché cell manganese di-oxide, and the chloride of silver cell chlorine.

The *depolarisation*, as we call this process, works perfectly in the chloride of silver or Daniell cell. Such cells are therefore called constant elements, compared with a chromic acid cell, for instance, in which the depolarisation is slower and less perfect, and which is called inconstant, because its strength of current decreases after a short time. A Leclanché cell is constant if it is worked for short intervals only or with weak currents; but it is inconstant if it has to yield a current too strong in proportion to its size, or if it remains closed for many hours without rest. In order to get a current of even strength out of an inconstant element, the size of the cell should be made rather large in proportion to the current it has to supply, in order to have always a spare surface which is not yet covered with gas.

Units.—It became necessary soon to introduce units, in order to be able to express in figures the amount of E.M.F., or the strength of current and the amount of resistance, etc. These measures were at first

arbitrary and varied in different countries; an International Congress of Electricians, however, decided this matter in Paris in 1881. It was agreed there to derive the electrical units from the generally recognised measures for length, weight and time (centimètre, gramme and second) in order to be able to compare the effects produced by electricity with those produced by other physical forces, such as magnetism, heat, light, etc., and moreover they agreed to name the different units for E.M.F., strength of current, resistance, capacity, etc., after the physicists, who have, by their great discoveries, materially developed the knowledge and usefulness of electricity, such as Volta, Ampère, Ohm, Faraday, etc.

The unit of the **E.M.F.** or potential, which has been chosen, is very near the E.M.F. of a Daniell cell, and has been called **Volt** (the E.M.F. of a Daniell cell is = 1·07 volt).

The unit of **resistance** is 1 **Ohm.** It equals the resistance of a mercuric column of 1 square millimetre sectional area, and 1·06 metre length at a temperature of 32° F.

The unit of **strength of current** is called 1 **Ampère.** It is the current which an E.M.F. of 1 volt produces in a circuit, the resistance of which is 1 ohm. A current of 1 ampère deposits 4·08 grammes silver per hour, or develops 171·9 cubic millimetres mixed gas per second, if sent through water. 1 ampère is too much for medical purposes, and therefore its one-thousandth part, or 1 milliampère, has been adopted as unit for measures of intensity, in accordance with a proposal made by Dr. de Watteville. A source of electricity with an E.M.F. of 1 volt passing through a circuit, the resistance of which amounts to 1,000 ohms, produces in it a current of 1 milliampère.

In the following pages the expression ampère hour is sometimes used; this means a current of 1 ampère for one hour, or 2 ampères for thirty minutes, or 1 milliampère for 1,000 hours, etc.

There exist other units besides these; for instance 1 coulomb is the work 1 ampère can do in one second; 1 farad is the unit for electrical capacity. For our purposes, however, there are only volts, ampères and ohms of importance.

Ohm's Law.—We have already seen in the previous statements that an E.M.F. of 1 volt produces 1 ampère in a circuit, the resistance of which is 1 ohm. If we increase the E.M.F., say to 5 volts, we shall find that the strength of current in the circuit has increased to 5 ampères. The strength of current increases therefore in the same proportion as the E.M.F. In increasing the resistance, however, the strength of current is diminished; 5 volts can send 1 ampère only through 5 ohms, or only ½ ampère through ten ohms, etc. The strength of current decreases in proportion with the increase of the resistance. This can be expressed by the formula:—

$$\frac{\text{Electro-motive force}}{\text{Resistance}} = \text{Current; or shorter, } \frac{E}{R} = C.$$

The resistance in this case means all the different resistances which are in the circuit, the resistance in the outer circuit as well as the internal resistance of the battery. This law, which is as simple as it is important, was discovered by Ohm, and has been named after him. It is the foundation stone of electrical measurements, and it is practically the only electrical law which has to be considered in using electricity for medical purposes. No knowledge of higher mathematics is needed in order to understand it, and he who takes the trouble to grasp and learn to use it, will be amply rewarded for his small pain by finding hardly any more theoretical difficulties afterwards in using and regulating his batteries. We will therefore devote a few more remarks to this subject, and quote a few examples.

1.—Thirty Leclanché cells, each of which has an E.M.F. of 1·5 volt, and an internal resistance of 0·8 ohm will, with an external resistance of 4800 ohms, yield

$$\frac{45 \text{ volts}}{(30 \times 0{\cdot}8) + 4800 \text{ ohms}} = 0{\cdot}0093 \text{ ampères or} = 9{\cdot}3 \text{ milliampères.}$$

2.—Should the same battery be used for electrolysis, a method where the resistance of the body is generally much smaller in consequence of the different size and application of electrodes, say 220 ohms, the current it would yield would be

$$\frac{45 \text{ volts}}{(30 \times 0{\cdot}8) + 220 \text{ ohms}} = 0{\cdot}1844 \text{ ampères or} = 184{\cdot}4 \text{ milliampères.}$$

3.—If the same battery is used for small incandescent lamps, such as are required for illuminating cavities of the body, the resistance of which varies between 8 and 25 ohms, the current with a lamp of 22 ohms resistance would be

$$\frac{45 \text{ volts}}{(30 \times 0{\cdot}8) + 22 \text{ ohms}} = 0{\cdot}978 \text{ ampères or} = 978 \text{ milliampères.}$$

4.—This current is sufficiently strong to render many of these little lamps incandescent, but if in consequence of polarisation, or of small crystals which cover zinc and carbon gradually, the internal resistance has increased up to 1·6 ohm, the battery would be too weak to bring the carbon filament to white heat, for

$$\frac{45 \text{ volts}}{(30 \times 1{\cdot}6) + 22 \text{ ohms}} = 0{\cdot}642 \text{ ampères or} = 642 \text{ milliampères}$$

5.—If the same battery is connected with a platinum burner, such as are generally used for galvanic cautery, and which have about 0·02 ohm resistance, the 30 cells will yield a current of

$$\frac{45 \text{ volts}}{(30 \times 0{\cdot}8) + 0{\cdot}02 \text{ ohms}} = 1{\cdot}8 \text{ ampères.}$$

a strength of current quite insufficient for making the platinum wire even warm, as the burners generally in use require a current of 9 to 16 ampères in order to get red hot.

6.—A bichromate battery with two *large* cells, however, which have got an E.M.F. of 2 volts each, and only 0·03 ohm internal resistance, will give with the same burner a current of

$$\frac{4 \text{ volts}}{(2 \times 0{\cdot}03) + 0{\cdot}02} = 50 \text{ ampères.}$$

7.—With the resistance quoted in example 1, these two large cells would still give only

$$\frac{4 \text{ volts}}{0{\cdot}06 + 4800 \text{ ohms}} = 0{\cdot}0008 \text{ ampères or } = 0{\cdot}8 \text{ milliampères.}$$

This example shows why the current of a battery with 2 or 4 large cells is sufficient to heat or even to fuse platinum wires, which offer a small resistance; whereas it is too weak to be felt at all if it passes through the high resistance of the human body.

8.—Two very small bichromate cells, which have the same E.M.F., but ten times more internal resistance, would give exactly the same amount of current as the two large cells with a *high* external resistance, for:

$$\frac{4 \text{ volts}}{0{\cdot}6 + 4800 \text{ ohms}} = 0{\cdot}0008 \text{ ampères or } = 0{\cdot}8 \text{ milliampères.}$$

We shall refer to some of these examples later on.

Ohm's law does not only help to find out the strength of current if the E.M.F. and resistance are known, it also enables us to find out the resistance, if we know the E.M.F. and strength of current. In this case, Ohm's law reads as follows:

$$\frac{\text{E.M.F.}}{\text{Current}} = \text{Resistance.}$$

9.—For instance, if the strength of current is 9 milliampères, and the E.M.F. of the cells used 41 volts, the resistance will be:

$$\frac{41 \text{ volts}}{0{\cdot}009 \text{ ampères}} = 4555{\cdot}5 \text{ ohms.}$$

Lastly, you can find out the E.M.F. if you know the resistance and strength of current. The formula then reads as follows: Strength of current × resistance = E.M.F. For instance:—

10.—If the strength of current is 184·4 milliampères, and the total resistance 244 ohms, as shown in example 2, you get

$$0{\cdot}1844 \text{ ampères} \times 244 \text{ ohms} = 44{\cdot}999 \text{ volts.}$$

Effects produced by the Electric Current.—Before closing these general remarks, we have to mention the principal effects which the current produces.

A magnetic needle is deflected from its direction towards north if a current circulates in its neighbourhood, a quality which is used to detect the presence of a current, and to measure the strength of it. A piece of steel or iron, round which a current passes, gets magnetic, and has consequently the power to attract other pieces of iron, steel, or nickel. Fluids are decomposed by the current. If we connect two metal or

carbon plates with a battery, and immerse them in water, the current will decompose the water ; oxygen gas appears at the plate connected with the positive pole (anode), and hydrogen gas on the plate connected with the negative pole (kathode). If the plates are immersed in a solution of metal oxides—for instance, sulphate of copper—metallic copper will be deposited on the plate connected with the negative pole. If we send the current through the human body, at the negative electrode, potassium, sodium hydrogen, etc., are liberated ; and at the positive electrode, oxygen, chlorine, acids, etc. Electrolysis has been chiefly investigated by Faraday, but its theory is very complicated, and not at all sufficiently solved yet. As far as we know, the chemical changes take place *at* the poles only, but *not between them*.

If electrodes are placed on the human body, and the current is suddenly closed, or suddenly broken, the muscles will contract. Flashes appear in the eyes, noises in the ears, and a peculiar taste on the tongue ; the irritability of nerves gets diminished near the anode, and increased near the kathode ; alternating currents of very high frequency produce local anæsthesia ; the circulation of the blood and the nutrition of the tissues gets stimulated.

The current heats metallic conductors, carbons, etc., in passing through them. Bad conductors get more heated than good ones. If a current of 12 ampères passes through a platinum wire of about 0·6 millimetre diameter, the wire gets red hot, so that it can be used for burning away tumours, etc. ; and if a current of about 0·75 ampère passes through the thin carbon filament of an incandescent lamp, the lamp gives a brilliant white light, which we use for illuminating our houses, and for examining cavities of the body.

APPARATUS FOR GALVANISATION AND ELECTROLYSIS.

The Resistance of the Human Body varies widely. If two small metal electrodes of one centimètre diameter each are placed on the *dry* skin, the resistance will be near 100,000 ohms. If we use, however, larger electrodes, about 5 centimètres diameter, cover them with leather, and place them on the skin, after having well soaked them in warm salt water, the resistance will not be more than about 3,000 ohms, and get less, within a short time, under the influence of the current itself. If we introduce an electrode into the rectum or vagina, and place a large electrode, 8 inches diameter, on the abdomen, the resistance will be about 150 ohms, or even less. The same result is obtained by pricking the skin with a few needles, for it is principally the skin which offers the great resistance, whereas the blood, etc., conduct comparatively very well. Still, we have at any rate 100, and in most cases 1,000 to 5,000 ohms

resistance to deal with, and therefore a large number of cells is indispensable, in order to obtain with these resistances currents varying between 1 and 100, or even more milliampères.

Which are the most suitable Cells?—It is not our intention to enumerate all the cells which have been invented since Volta till to-day. On the other hand, it is impossible to give the preference to one certain cell under all circumstances, as the wants and wishes differ very much. *Any* cell can be used which is capable of yielding the desired strength of current, but if we consider convenience, the time necessary to keep a battery in working order, its portability, etc., the number of useful cells will be reduced to very few indeed, and these few only will be mentioned here.

In choosing a battery, it is a consideration whether it can be charged by the proprietor himself, or whether it has to be returned to the maker when exhausted. In the latter case, the battery would be suitable for those medical men only who live in convenient reach of the manufacturer. The capacity of the battery, *i.e.*, the amount of current which it will yield before having to be recharged, the cost of recharging, the price of the battery, and its size and weight, are important.

E.M.F. of the Cells.—It stands to reason, that cells with high E.M.F. and small internal resistance have a considerable advantage over cells with low E.M.F. and high internal resistance; for 50 chloride of silver cells with 1 volt and 8 ohms internal resistance each, will yield with an external resistance of 2,500 ohms,

$$\frac{50 \text{ volts}}{(50 \times 8) + 2500 \text{ ohms}} = 0{\cdot}0172 \text{ ampères, or } = 17{\cdot}2 \text{ milliampères,}$$

whereas 22 bichromate cells of 2 volts and 0·3 ohm each would yield in the same case

$$\frac{44 \text{ volts}}{(22 \times 0{\cdot}3) + 2500 \text{ ohms}} = 0{\cdot}0175 \text{ ampères, or } = 17{\cdot}5 \text{ milliampères.}$$

In order to obtain 17 milliampères with 2,500 ohms external resistance, we should therefore require 50 cells of 1 volt each, whereas the same result could be obtained already with 22 cells of 2 volts each; and, of course, with this latter kind of cells, the batteries are smaller and less expensive in every way, on account of the smaller number of cells.

The cells most frequently used may be classified in two groups: Cells which contain acids, and where the zincs therefore have to be taken out of the fluid after the battery has been used—Plunge Batteries; and cells, the exciting fluid of which does not attack the zinc as long as the circuit remains open, and in which, consequently, the zinc may remain constantly immersed in the exciting fluid.

Leclanché Cells.—Let us first consider the cell which is more used than all the other cells taken together—the Leclanché cell. For galvanisation and electrolysis, there can hardly be found a cell more reliable, and in every way more convenient than the Leclanché cell, provided

that its size be not reduced too much for portability's sake. Its E.M.F. is good, 1·5 volt, and the internal resistance is moderate, 0·4 to 1 ohm, according to the size of the cell. As long as the circuit is not closed, there is theoretically none, and, practically, very little local action. It is always ready for use, and a well constructed cell will last for over two years without having to be seen to during this time. Moreover, every part of these cells is so easily accessible that they can be cleaned and refilled without technical aid. In order to clean Leclanché cells, the crystals which stick to the carbons and zincs have to be scraped off with a knife, carbon and glasses should be washed, and after the cells have been put together again, they are refilled with a saturated solution of pure sal ammoniac.

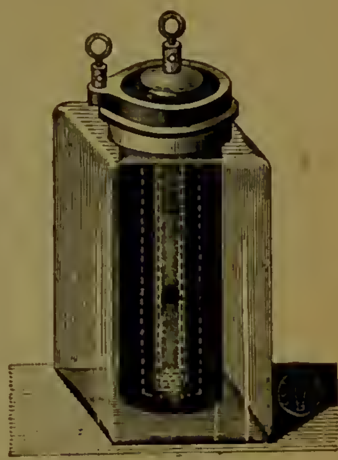


Fig. 1.

With Leclanché cells, as with most other cells, it is of the greatest importance not to select them smaller than absolutely necessary, for the smaller they are made the less satisfactory they get. Many attempts have been made to make them as small as 1 by 1 by 4 inches, but they have invariably failed up to now. The constancy of such small Leclanché cells is insufficient, and for various reasons the local action is greater in the small cells than in the large ones.

Dry Leclanché Cells.—If portability has to be considered, the dry cells, which belong to the Leclanché type too, have great advantages over the cells containing fluid, for there is no liquor to be spilled or to corrode the brass parts, and there is no glass, etc., to get broken. Their internal resistance is a little lower, and their E.M.F. a little higher than that of the liquid Leclanché cells. They can be sent charged all over the world, and are very suitable for all batteries which have to be carried about frequently.

Their only disadvantage is that the cells, after being exhausted, cannot be recharged, but have to be replaced by new ones, and this makes the refilling rather expensive. On the other hand, batteries filled with *good* dry cells will certainly last for fully two to four years without requiring recharging, and they are less likely to require repairs than those filled with liquor, because accidents like the smashing of glasses, and spilling of corrosive fluids cannot happen, so that the difference in the cost of maintaining the batteries is not quite as great as it appears at first sight. The new cells can be sent by post, and can easily be put into the place of the old ones, so that the battery itself need not be returned to the maker.

It is an important question which of the many dry cells at present on the market are the best. Comparative tests of various types have been published in electrical papers, but though we have no doubt that

the experiments were made by competent men in good faith, we nevertheless consider most of these experiments as misleading, for they refer only to *new* cells, while for our purposes it is of little interest what the cells will do while they are *new*, whereas it is all important how they will *keep* and what they will do when one, or two, or more years old. We have had samples of most of the existing dry cells, but as far as our experience as to *durability* is concerned, Hellesen and Obach's cells seem to surpass all the others. An example will show this best. We have taken 6 new Obach cells (S size) and 6 cells of another frequently used type, of the same size and shape, which we will call the C cells. The cells gave the following results :—

External Resistance.	October, 1895.	October, 1896.	January, 1899.
Obach cells 1,000 ohms ...	1·5 M.A.	1·4 M.A.	1·2 M.A.
" " 100 " ...	15·0 "	14·0 "	10·0 "
" " 10 " ...	140·0 "	125·0 "	65·0 "
C " 1,000 " ...	1·5 "	1·1 "	0·0 "
" " 100 " ...	14·0 "	10·0 "	0·0 "
" " 10 " ...	140·0 "	50·0 "	0·0 "

This shows that the Obach cells have lost not more than about 3 per cent. in one year, while the C cells have lost 60 per cent. and are practically useless.

If another proof were wanted it is this : we have sold, during the last six years, many thousand Hellesen and Obach cells, and not a single complaint has reached us about batteries charged with these cells. (N.B. we refer here to batteries for *galvanisation and electrolysis only.*)

Acid Cells.—As far as cleanliness and convenience are concerned the acid cells have decided disadvantages compared with Leclanché cells. As they must be plunge elements, the vessels cannot be so well closed, and evaporation and spilling cannot be prevented altogether; although lately these defects have been considerably improved by means of suitably shaped vessels and india-rubber floats. With daily use an acid battery has to be cleaned and refilled about once in every three months. The refilling, however, may be easily performed even by the most inexperienced. As the acid batteries require less skill to be kept in order than any other battery, they are especially suitable for use in those countries where technical help is difficult to be had, such as the Colonies, and, moreover, for those medical men who do not use their batteries regularly. It takes no more than an hour to clean the battery and put it in working order again, even if it has stood unused

in a corner for years. They have, moreover, the advantage of being very powerful. They have a very high E.M.F., 2 volts, and less than 0·05 ohm internal resistance, so that 22 acid cells are even stronger than 30 Leclanché cells. They are specially suitable for the strong currents required for electrolysis. The zincs last several years with average use, and can be easily replaced without technical help, so that the owner of such a battery is really independent of the maker. All acid cells consist of carbon and zinc, and various solutions are recommended for them ; we prefer a solution of 1 oz. of bichromate of potassium, 20 ozs. of water, 2 ozs of strong sulphuric acid, and 1 oz. of bisulphate of mercury. In order to clean the cells, the vessels have to be filled with water, and the elements should be left soaking in them, over night, to dissolve crystals, etc.

Number of Cells.—The number of cells a battery ought to have depends on the purposes for which it is required. Specialists for eye, ear, and throat diseases will be able to obtain the strongest currents usually applied to the head with 18 to 24 Leclanché cells ; that is, with 25 to 35 volts. General practitioners, surgeons and specialists for gynæcology use as a rule batteries of about 40 volts, and 50 to 80 volts are necessary for diagnostic purposes and for the treatment of nervous and paralytic diseases.

A suitable number of cells alone is not yet sufficient for a medical man ; there have to be different appliances for regulating the strength of current, for interrupting, reversing, and measuring the current, and for applying it to the body. The strength of current can be regulated in two ways ; either by varying the E.M.F., or by means of artificial resistances. The first mentioned method is more frequently used, and is managed with the help of the current collectors.

Current Collectors.—The current collectors help to increase or diminish the number of cells in the circuit, thus changing the E.M.F., and regulating the strength of current. They ought to be constructed so that the current is never interrupted while the number of cells is being changed, as this would give disagreeable shocks. This demand is often the cause why elements are destroyed, as we shall see later on. Moreover the cells should be put in the circuit one by one, not five by five, etc., as this would also cause shocks.

Crank Collectors are most frequently used. A number of pegs, equal to the number of cells in the battery, are arranged in a circle, so that a crank can be brought in contact with every one of these pegs. The cells are connected with these pegs ; a wire leads from the first zinc to the negative terminal, another wire from the carbon of the first cell to peg 1, another wire from the carbon of the second cell to peg 2, etc., and one wire leads from the crank to the positive terminal. By turning the crank the number of cells connected with the terminals can thus be conveniently increased or diminished. In order to avoid interrupting the

current, the pegs are so arranged that the crank touches the next peg before having quite left the former one.

As long, however, as the crank touches two pegs, for instance pegs 5 and 6, *at the same time*, the sixth cell is short circuited, for the current can pass from the zinc of cell 6, which is connected with the carbon of cell 5, on to peg 5, through the crank to peg 6, and from there back to the carbon of cell 6, without finding on its way any resistance worth mentioning. If this state lasts but very shortly, it causes no damage, but if it lasted for any length of time, the short circuited cell would be exhausted. It is therefore important with all crank collectors, not to let the crank rest so that it can touch two pegs at the same time, as Fig. 2 shows; the crank should always touch one peg only, as shown in Fig. 3. The number next to the peg on which the crank rests shows the number of cells in action. This kind of collector is convenient, but they have one drawback yet, especially if used with batteries containing a great number of cells, viz., that by being always put in the circuit, the first cells of the batteries get used up quicker than the last ones.

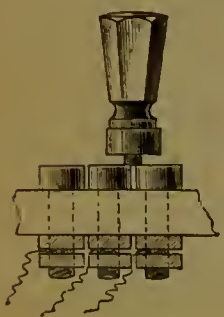


Fig. 2.

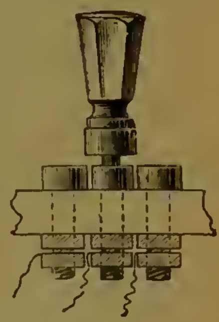


Fig. 3.

Double Collector.—In order to avoid this drawback, I have constructed the double collector. It has two cranks, which are placed on the same axis, but are insulated from one another, and the zinc of the first cell is not connected any more with a terminal, but with an additional peg 0. One crank is connected with the positive, and the other with the negative terminal. By means of these two cranks any batch of cells may be inserted, and thereby the whole battery can be used up evenly. An index fitted to one of the cranks points to a division, thus showing the number of cells in action. Finally, by means of the double collector, each single cell can easily be connected with a galvanometer, and tested, so that damaged or exhausted cells may be found out without trouble. In this way the double collector is a great convenience in testing the battery, and no doubt it is the best current collector known up to now.

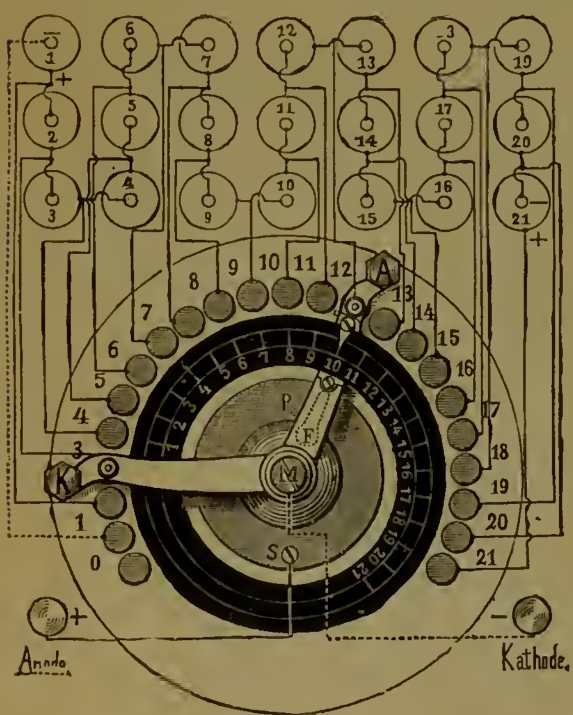


Fig. 4.

Rheostats.—Batteries provided with a good current collector need no rheostat as a rule, but for eye, brain, ear, and dental purposes a rheostat may be wanted. Rheostats may be used instead of the current collector as a means of regulating the strength of current. In order to reduce the current of a battery of 45 volts to about ½ milliampère, the resistance required would be, according to Ohm's law :—

$$\frac{45 \text{ volts}}{0{\cdot}0005 \text{ ampère}} = 90000 \text{ ohms},$$

and it should be possible to diminish this resistance *gradually*, in order to avoid all shocks in increasing the currents.

Liquid Rheostats.—Liquid rheostats have the advantage of cheapness. They consist generally of a glass tube, the lower end of which is closed with a piece of platinum, which acts as one electrode. The second electrode is a piece of zinc, which may be moved up and down in the glass tube. If the tube is filled with some badly conducting liquid, and the piece of zinc is drawn out as far as possible, the resistance is greatest. The number of ohms depends on the length of the tube, the diameter of the electrode, and the conducting capacity of the liquid. The resistance gets diminished by moving the zinc downwards. As decomposition must take place in these rheostats too, small gas bubbles form on the electrodes, changing the surface of the electrodes and the resistance continually. In order to prevent this, a depolarising substance, for instance, chloride of zinc, is mixed with the water. A weak solution of chloride of zinc, however, depolarises only a little, and would therefore prevent the gas bubbles only with very weak currents ; but a strong solution of chloride of zinc conducts pretty well, and in order to obtain, nevertheless, a high resistance, the glass tube would have to be very long, a thing which is impossible with portable batteries, and on account of these difficulties, the use of liquid rheostats will always be limited.

Metal Rheotsats.—Metal rheostats are most frequently used. They are the only suitable ones for measuring purposes, as they are the most accurate and the least subject to changes. The metal rheostats for medical purposes are provided with a crank like the current collectors ; each peg is connected with its neighbours with long and fine German silver wire, through which the current has to pass, till it reaches the peg on which the crank rests. In order to obtain high resistances without making the number of ohms between the various pegs too great, a good many pegs are necessary. As a rule several crank rheostats are arranged so that the first increases the number of ohms 10 by 10 up to say 200 ohms, the second 100 by 100 up to 2,000, &c. Such rheostats are convenient, but they are big and costly. They are, as a rule, used for the more expensive office batteries only

Graphite Rheostats.—Convenient and inexpensive rheostats of low or high resistances may be made of graphite, and they can be so arranged that the current can be varied without giving any shocks. The only disadvantage of graphite rheostats is that the conducting capacity of the graphite varies ; this makes these rheostats quite unfit for measuring purposes, but it is of no importance for rheostats required only for regulating the strength of currents, and certainly the graphite rheostats are up to now the most suitable resistances for portable batteries. They are best made of lead pencils ; the length which the current has to pass through can be varied conveniently by a spring gliding on the pencils as shown in the illustration.

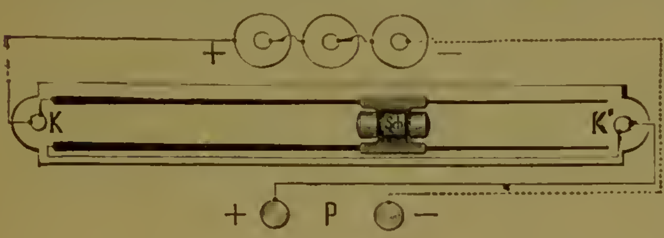


Fig. 5.

Galvanometers.—The great value of galvanometers for medical purposes has been so universally recognised in recent years, that it will hardly be necessary now to say much in their favour. Their purpose is to measure the strength of the current *while it passes through the patient*, and to enable the physician to dose the current accurately, notwithstanding the great difference in the resistance and the sensation in different

patients, and notwithstanding the changes and differences of batteries. For administering electricity properly, they are about as important as a scale is for administering drugs; and there is good reason to say, that their introduction through Drs. v. Ziemssen, De Watterville, Edelmann and Gaiffe, mark a turning point in electro-therapeutics.

Horizontal or Vertical Galvanometers?—When galvanometers first came into use, the vertical form was preferred because it is certainly easier to read from a vertical scale than from a horizontal one. But it was soon discovered that vertical galvanometers with *permanent* magnets are unreliable, in consequence of the changes in the magnetism of the needles. The magnetism of the needles changes, but the directing power of the weight (or magnet) which causes the needle always to return to the 0 point, does not change. The changes of magnetism occur certainly in horizontal galvanometers too, but here they have no influence on the accuracy of the division, for, if the amount of magnetism in the needle were to change after the graduation, the directing influence of the earth's magnetism, and the deflecting influence of the current, change in exactly the same proportion, and thus the angle of deflection remains the same. The horizontal galvanometers came therefore into general use. For about 10 years they were the only reliable instruments known; in these last years, however, a new kind of galvanometer has been constructed which can be used in any position. These instruments will be described later on as d'Arsonval's galvanometers.

Suspension of the Magnet.—The inertia is slightest in the case of instruments the magnet of which is suspended on a cocoon fibre, and in this case the friction also remains always the same. Such instruments have therefore the great advantage, that in the case of their graduation being correct for a certain locality, this graduation will always remain correct and reliable.* These are, no doubt, the most sensitive instruments, as currents up to $\frac{1}{10}$th or even $\frac{1}{100}$th of a milliampère can be measured. In all cases where perfect accuracy is required, only such apparatus should be used. As these instruments are somewhat delicate and expensive, we employ for portable batteries, galvanometers the magnets of which are suspended on a steel point, as in a compass. Ordinary sewing needles are used now for this purpose, which can be easily replaced by new ones from time to time in order to keep them sharp and the instrument sensitive.

D'Arsonval Galvanometers.—The galvanometers described up to now are provided with a movable horse shoe magnet, which is deflected

* This is not literally correct, as the terrestrial magnetism also varies and gradually increases. For instance, in London the earth-magnetism at the present time is about 1·82, and, if the increase of the latter continues at the same ratio as hitherto, it will be about 1·86 in ten years. A galvanometer, which now shows with perfect accuracy a current of 10 milliampères, would then with the same current, at this increased ratio of intensity of earth-magnetism, not indicate more than 9·97 milliampères, thus being 2 per cent wrong.

from its direction toward the north pole by an electrical current circulating in its neighbourhood. Lord Kelvin suggested to replace this permanent magnet by a solenoid, and other scientists made practical use of this idea. Many turns of a fine insulated wire are wound on a frame of aluminium which is suspended between 2 points so that it can move freely. Two hair springs keep the frame in a certain position, and at the same time conduct the current to the solenoid. As long as a current passes through the solenoid it is attracted or repelled according to the polarity, by a current circulating in the neighbourhood, and the elasticity of the hair springs is the power which has to be overcome and which brings the frame back to its original position as soon as the current ceases. These galvanometers are therefore quite independent of the terrestrial magnetism, and can be used in horizontal, vertical, or any other position. Moreover, they are protected by a horse shoe magnet which acts as a screen against disturbing influences from outside. The galvanometers with a magnet dependent on the north pole are so much influenced by the currents supplied for lighting houses, that it is impossible to take exact measurements in houses lit by electricity, whereas these new galvanometers remain correct even in close proximity of dynamos.

These advantages render the d'Arsonval galvanometers specially useful for all apparatus utilizing currents from the main; they are, however, equally convenient for batteries, their only drawback is that they are more expensive than the galvanometers with horse shoe magnet.

Shunt.—According to Dr. de Watteville's suggestion, all medical galvanometers are divided into milliampères. In order to be able to measure weak currents for galvanisation as well as strong currents for electrolysis with the same instrument, most galvanometers are fitted with one (or two) shunt, which can easily be switched on and off. As long as this shunt is not used, the whole current has to pass through a long fine wire, which is arranged so as to make the magnet decline from the magnetic meridian. If, however, the shunt is brought into action, by screwing a screw marked 10 home, the current finds another passage through a short and thicker wire, which is wound so as *not* to influence the magnet, and in this way, two paths being open to the current, it will divide itself among both, so that its strength in each branch is inversely proportional to the resistance of the wire. If, for instance, the resistance of the shunt wire is chosen so that its resistance is $\frac{1}{10}$th of the resistance of that wire which makes the needle decline, only $\frac{1}{10}$th of the

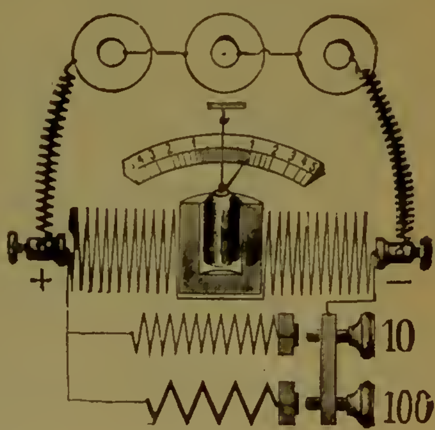


Fig. 6.

current will flow through the latter wire and $\frac{9}{10}$ths through the shunt wire. The magnet, therefore, will be influenced by only $\frac{1}{10}$th of the current which actually passes through the galvanometer, and consequently the numbers indicated on the dial have to be multiplied by ten in order to find the real strength of the current. A galvanometer, for instance, which, without the shunt indicates up to 25 milliampères one by one, will, if the shunt is used, show up to 250 milliampères 10 by 10. The resistance of the shunt can also be so arranged, that the numbers on the dial have to be multiplied by 100.

Voltmeter.—If the resistance of a milliampère meter has been increased up to 1,000 ohms, it can be used for measuring E.M.F's., for as a current of 1 volt produces 1 M.A. in 1,000 ohms, the number of milliampères are equal to the number of volts *as long as the resistance in the circuit is* 1,000 *ohms.* The body of a patient, or any other unknown resistance, must therefore *not* be in the circuit while the E.M.F. of the cells is being measured.

If the strength of current obtained through a patient is known, and the E.M.F. of the cells which has been used to produce the above strength has been measured in volts in the way just mentioned, the resistance of the patient can be found out with the formula :—

$$\frac{\text{E.M.F.}}{\text{Current}} = \text{Resistance.}$$

(See example 9, *page* 8.*)*

A galvanometer, the sensitiveness of which has been reduced by screwing home the shunt, is of course insensible to weak currents ; on the other hand, however, one single cell is already sufficient to deflect the needle of a galvanometer to a right angle, as long as there is not the resistance of a patient in a circuit.

Current Reversers, Current Combiners.—It is important for most physicians to possess an arrangement which makes it possible suddenly to close or interrupt the current, or else suddenly to connect with the negative pole the electrode hitherto connected with the positive pole, and *vice versa.* These sudden changes produce contractions of the muscles, the intensity of which depends on the strength of the current, and the sensitiveness and healthiness of the muscle. They are therefore very important for diagnosis. To interrupt and to reverse the current can be managed with one single instrument, of which we add a diagram.

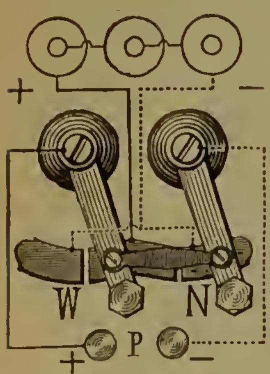


Fig. 7.

The negative pole of the battery is connected with W and N, the positive pole with the metal piece between these two. While the crank points towards N (normal), as the drawing shows, the crank on the right hand side is connected with the negative pole, and the crank on the left hand side with the positive pole. By moving the cranks slightly to the left, so that they rest on W and N, both cranks are

in contact with the negative pole, consequently there is no current at all ; but if we move the cranks further, so that they point towards W, the left hand crank is connected with the negative, and the right hand crank with the positive pole. From each crank a wire is leading to a terminal screw. Current reversers are manufactured in many shapes, but in principle their construction is always the same.

Current Alternator and Combiner.—In order to be able to change the continuous or the faradic current suddenly, without having to connect the electrodes with other terminals, and in order to be able to apply at the same time continuous and faradic currents combined, Dr. De Watteville has suggested a convenient apparatus, which outwardly resembles a current reverser, and of which we add a diagram too (Fig. 8). While the cranks point to G, the galvanic current is connected with the terminals ; while the cranks point to F, the faradic current is connected with the terminals ; and while they stand half way (G F), the galvanic and faradic currents are connected with each other in series, *i.e.*, the continuous current has to pass through the bobbin of the induction coil and the patient, and the faradic current has to pass through the patient and all the cells of the continuous current battery. Thus both currents pass through the patient at the same time.

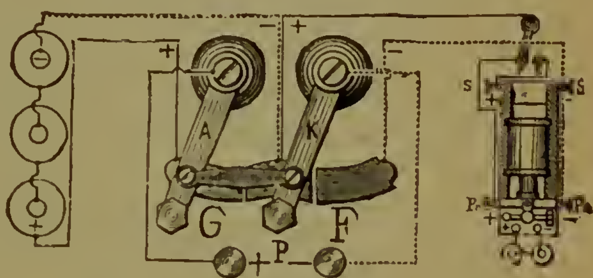


Fig. 8.

Cords.—Two connecting cords of suitable length, covered with some insulating material, are necessary for conducting the current from the battery to the patient. Insulated copper wire, which is bare for half an inch at both ends, is sufficient ; but, on account of the greater flexibility, cords made of some twelve very fine wires, terminating on both ends in short and thick wires, are mostly used. They are to be fastened in the handles and in the terminals of the battery. These short wires should not be soldered on to the cords, as soldered parts stand no bending, and would soon break ; a ball joint, however, is convenient and durable. Some prefer the cords to be insulated with india-rubber tubes, some others with silk or cotton. In the former case the cords are well protected against moisture, but the india-rubber contains sulphur, which makes the copper brittle. India-rubber covered cords do not last longer than one or two years, whereas silk or cotton-covered cords last for a long time, provided they are not soaked in water together with the electrodes.

Handles.—The handles are provided with a terminal for the reception of a connecting cord, and with a thread fitting the electrodes. They are always provided with an insulating handle, so that the physician holding them is not exposed to the action of the current. Many handles

are provided with a trigger, for making or breaking the current; this can conveniently be managed on the handles with one finger only, whereas a hand is required to work an interrupter on the battery. There are also handles which contain a current reverser or a rheostat, but they are complicated, and are of real advantage in very few cases only.

Electrodes.—There exists a great variety of electrodes: buttons, round and square plates of all dimensions, made of tin, aluminium, or carbon, and covered with flannel or chamois leather, which may be screwed on to the handles, or have a terminal to receive the cords direct. Through frequent use—the moisture and the oxide—the covers get soiled, and should be renewed from time to time, and the oxide has to be removed from the metal plates with emery paper. Brushes of fine metal wire are used for exciting the muscles and nerves of the skin; wheel electrodes for conveniently changing the place of application, and for combining massage and electricity. Small metal knobs on long

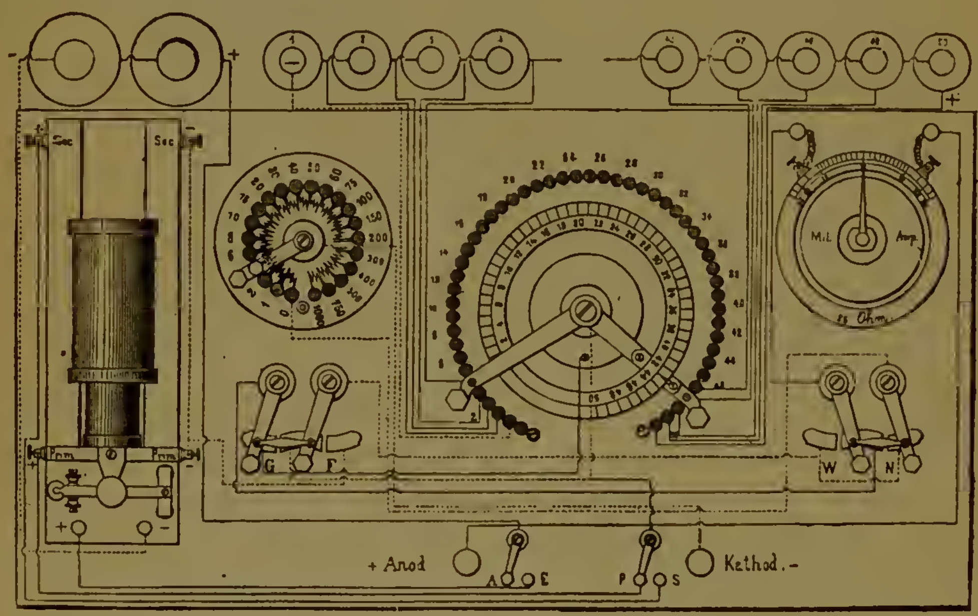


Fig. 9.

Diagram of the Connections of Battery No. 139.

insulated wires are in use for conducting the current to the larynx, nose, rectum, vagina, uterus, etc., and for treatment of strictures. Needles are employed for destroying hairs, nævi, tumours, etc. All these electrodes get polarised, and all electrodes made of common metal are subject to oxidation; they ought therefore not to be placed on the mucous membrane unless they are connected with the negative pole. To be used with the positive pole, the electrodes used for electrolysis should be of carbon, gold or platinum.

Density of the Current.—The size of the electrodes is of considerable importance. The larger the electrodes, the smaller is the resistance of the human body. With electrodes of ten square inches twice the

current can be sent through the body than with electrodes of five square inches surface under otherwise equal conditions. This leads us to the density of the current, or, in other words, the proportion of the strength of current to the sectional area of the conductor. If, for instance, with electrodes of three square inches surface 20 milliampères are passing through the body, the current is three times as dense as if electrodes of nine square inches and the same strength of current were used; in other words, in the first case each square inch of the places of application receives 6·6 milliampères, whereas in the second case only 2·2 milliampères are received by the same area. The physiological and chemical effects would in the first case be three times as strong on and near the place where we apply the electrodes as in the second case. Statements that such and such results have been obtained with so and so many milliampères are therefore incomplete, unless the diameter of the electrodes used, and the time of application are mentioned as well. On entering the body the current divides itself into numerous loops and branches, and follows the best conducting parts till it reaches the other electrode. The density is greatest where the two electrodes touch the body; it is a little less near the straight line connecting the two electrodes, and smallest in those parts of the body which are most distant from the electrodes; but experiment shows that even those parts are reached by some small part of the current.

The effect of the current is frequently desired in one definite spot only, but as we necessarily require two electrodes to complete the circuit, they are chosen of very different diameter: a small one (active electrode), to concentrate the current on the nerve or muscle, etc., which is to be influenced by the current, and a large one (called the indifferent electrode), which may be applied to the hands or any easily accessible part of the body. If the latter electrode is chosen sufficiently large, undesired effects, such as pain or blisters, etc., will be avoided.

Electrolysis.—This is of special importance if the chemical properties of the current are to be used for destroying any tissues, etc., (electrolysis). If, for instance, a needle connected with the negative pole is inserted close to a follicle, and an electrode of two inches diameter, connected with the positive pole, is held with the patient's hand, the current is of course equally strong in both electrodes; but in the one the whole effect of the current is concentrated on a needle's point, and the chemical action of 1 milliampère suffices already to destroy the follicle, so that the hair can be extracted after a few seconds. The chemical action on the other electrode, however, is divided over so large a surface that the current mentioned will leave no visible effect.

Faults.—It is not an easy undertaking to describe in a few words the faults which may occur in a battery, and how they can be found out and rectified. The preceding sections, explaining the batteries and accessories will enable anyone who takes an interest in his instruments

to find out the reason of any disturbance; whereas for him who does not trouble to learn to understand the anatomy of his battery, any number of pages about this theme will be insufficient, for he will ever remain dependent on the help of an elect· :ian. If a battery does not work, the only reasonable thing to do is to ascertain where the fault is, whether it is in the cells, or in the connection between the cells and the terminals, or in the cords, handles, etc. Most frequently the fault will be found in the connecting cords. They are liable to break, and this shows itself by their too great flexibility, they are cut off then up to the unspoiled part. In all batteries with a great number of elements, a spark appears if the two ends of the connecting cords are brought in contact and separated again. If no spark is seen, fasten one end of a cord to a terminal, and touch with the other end the other terminal. If still no spark is visible, touch peg 1 with one end of a cord, and with the other end touch the last peg of the collector, and if there is still no spark, try with groups of say five elements each, either on the pegs of the current collector or directly on the terminals of the cells. If the elements are not very old, a spark will be obtained from several of these groups, and the faulty cells may be singled out. A whole battery may fail because one of the many screws on the cells may have got loose, on account of differences of temperature or shaking in the transit, for a loose screw no longer makes any contact with the wire which connects the cell with the next one. This can easily be rectified by tightening the screw. Another reason may be, that in consequence of short circuit (caused by a wrong position of the current collector, or by a fault in the cell) a zinc is eaten through, or that the fluid has escaped through a crack in the element vessel. In both cases the connection is interrupted, and the defective cell or cells have to be removed and refilled, or replaced by new ones; if this is impossible at the time, the last cells of the battery may be taken off and put in place of the defective ones, until new ones can be obtained. (Batteries which are so constructed that each single cell can be taken out, are for this reason much better than those in which the cells are soldered together, or otherwise inaccessible, for if one single cell in them goes wrong, the whole battery has to be sent back to the maker.) A galvanometer makes it much easier to find such a fault; the cords are connected with the galvanometer, and the other ends are placed first on pegs 1 and 2, then on pegs 2 and 3, etc.; in this way each cell can be tested, and a fault found out at once. In batteries provided with a double collector it is simpler still. The tongue is a sensitive galvanoscope, too. If we touch with it two wires connected with a cell, we feel a peculiar taste if the cell is working. We strongly recommend, however, to try this experiment with groups of not more than ten cells only, for we heard of a case where a doctor, believing that his patient got no current from a 40 cell battery, put the cords on his tongue, and remained unconscious for three-quarters of an hour in consequence of the shock.

It is rare that a fault occurs in the connections between the cells and the current collector, the wires being mostly well protected and all the invisible connections being soldered. The pegs of the current collector as well as the current reverser, are liable to get oxidised, especially in acid batteries, and have to be cleaned occasionally with fine emery paper; dust between the pegs should be removed with a fine hair brush. The screws which keep the crank of the current collector and reverser on their axes may get loose and have to be tightened. The handles with an interrupter may fail to make contact through oxidation, or through the spring being loose. *Cords, handles or wet electrodes ought never to be placed on the current collector, etc., as they may cause short circuit.*

We have yet to mention the faults which are caused by false application. Some people believe in being able to test a battery if they touch with dry fingers the varnished terminals, or else the ends of the connecting cords. Of course, in both cases, the current is exceedingly weak on account of the very high resistance, and can hardly be felt even by experienced persons. Currents of a few milliampères are felt by most patients only if they are suddenly closed or broken, and whenever a battery is tested, the only proper way to do it is to soak the electrodes in warm salt water, and to apply them as in real use.

Current supplied from Dynamos.—The apparatus required for utilising the currents supplied for lighting houses, for galvanisation and electrolysis are explained on pages 44—54.

BICHROMATE BATTERIES FOR GALVANIC CAUTERY, SPARK COILS, &c., INSTRUMENTS FOR GALVANIC CAUTERY.

A very strong current is required for rendering platinum wires, of the thickness needed for cautery operations, incandescent, for most of the burners require 10 to 15 ampères (10,000 to 15,000 milliampères) and in order to keep a current of this strength constant, even for a few minutes only, *large* cells are absolutely necessary. On the other hand, platinum burners have a very low resistance—burner, handles and cords together about 0·06 ohm. If the cells have a small internal resistance too, for instance, 0·06 ohm per cell, two cells of 1·5 volt each are already sufficient for producing the necessary strength of current with these resistances, for

$$\frac{3 \text{ volts}}{0{\cdot}06 + 0{\cdot}12 \text{ ohm}} = 16{\cdot}6 \text{ ampères.}$$

The requirements for cautery are therefore totally different from those for galvanisation and electrolysis. In the latter case many cells are

needed to force even a weak current through the high resistance of the human body. The cells, however, can be small, because even the strongest current used for electrolysis rarely exceeds 200 milliampères. For cautery, however, the E.M.F. of two cells is already sufficient on account of the very small external resistance, but the cells have to be of large size, as the current required must be more than 1,000 times as strong as the currents generally used for galvanisation. Even a 100-cell Leclanché battery with cells of 0·6 ohm internal resistance, would give only

$$\frac{150 \text{ volts}}{60 + 0{\cdot}06 \text{ ohm}} = 2{\cdot}49 \text{ ampères.}$$

This explains why a battery made for galvanisation cannot be used for cautery, and why a cautery battery cannot be used for galvanisation, notwithstanding its big cells—two questions which are very frequently put to us.

Connection of Cells.—Up to now *one* method of arranging the cells has been mentioned only, the connection "*in series*," for high external resistances. The cells can, however, be arranged so that the carbon of the first cell is connected with the carbon of the second, and the zinc of the first with the zinc of the second cell, etc., and this is called connecting the cells "*parallel.*" The E.M.F. *does not* increase thereby, no matter how many cells are connected in this way, but the surface of the metal or carbon plates increases, and consequently the internal resistance diminishes, with each additional cell. Two cells connected in this way are equal to one single cell of double size, and this is a great advantage for galvanic cautery, for by lessening the internal resistance we enable it to yield, with small external resistance, a stronger current. Principally, however, we double the constancy, for large plates do not polarise as quickly as small ones do, and the capacity in ampère hours of two cells connected parallel, is twice as large as the capacity of two cells connected in series. There are yet some other combinations possible. We can, for instance, connect 6 cells, of 1·5 volt, 0·15 ohm internal resistance, and 20 ampère hours capacity each, in series, and obtain then 9 volts, 0·9 ohm internal resistance, and 20 ampère hours; or else we can connect every two cells parallel, and the three double cells in series. We then obtain 4·5 volts, 0·225 ohm, and 40 ampère hours; or 3 cells parallel and the two

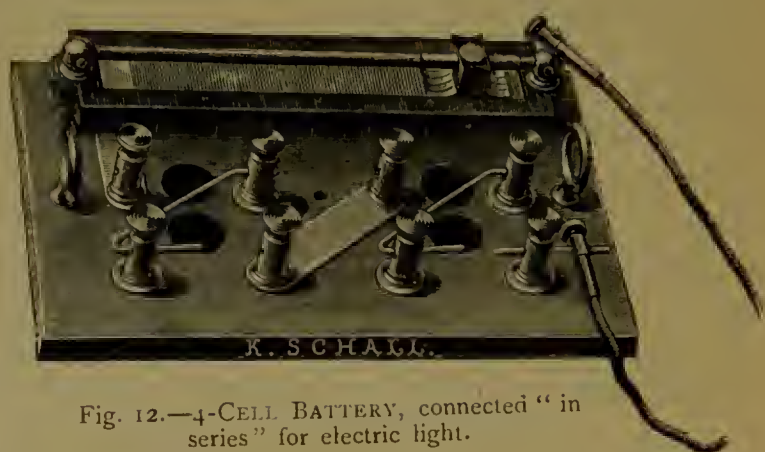


Fig. 12.—4-Cell Battery, connected "in series" for electric light.

groups in series, which would give 3 volts, 0·10 ohm, and 60 ampère hours; and lastly we can connect them all parallel, and would then obtain 1·5 volt, 0·025 ohm, and 120 ampère hours. The mixed connection is the most convenient one for cautery batteries, and is most frequently used. The two diagrams show the two different ways of connecting the 4 cells of a frequently used cautery battery. As already mentioned, the E.M.F. of two cells is sufficient to produce with so small a resistance the necessary strength of current; for wire loops, however, 3 to 4 cells are necessary, and the batteries most frequently used for cautery have 4 cells. If batteries are constructed with more than 4 cells, this is partly done in order to be able to connect the cells parallel in the way above mentioned, and partly to use them for the production of a strong light as well. We shall refer to this later on under the section for electric light.

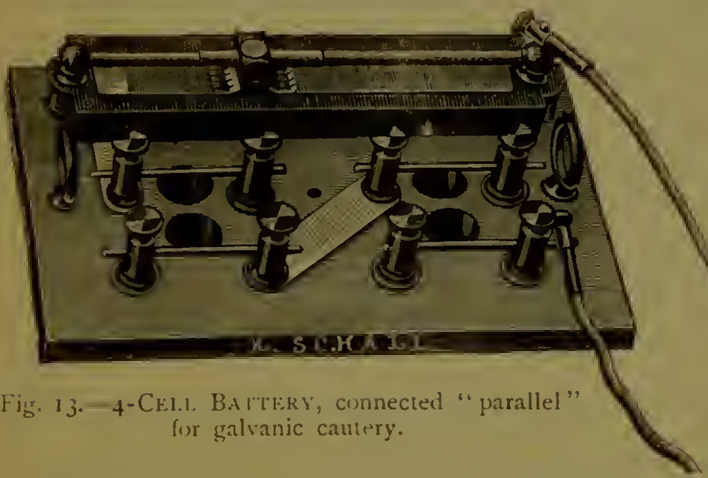


Fig. 13.—4-CELL BATTERY, connected "parallel" for galvanic cautery.

Which are the most suitable Elements?—There is no great variety of cells with a sufficiently small internal resistance. Cells with two different acids, such as Bunsen and Grove cells, are certainly very powerful and constant, but as they have to be emptied and cleaned each time after having been used, they have long since been put aside as too troublesome for surgical purposes.

Bichromate Cells.—Bichromate elements are most frequently used for cautery. The chief objection to them is their want of constancy. If, however, the cells are not made too small,* they are sufficiently constant for all cautery operations; for a cell of 3 by 5½ by 6½ inches, will keep a burner requiring 12 ampères incandescent for, approximately, twenty minutes. They are powerful, their E.M.F. being 2 volts, and they are easily put in action. And especially they can very quickly be re-filled, and can be easily kept in order by anybody, so that they are very suitable for medical men who do not wish to be dependent on the

* The peculiar type of bichromate cells known as "bottle elements" have made bichromate batteries famous for inconstancy. In these bottle elements, carbons and zincs are put together as closely as possible, so that they can pass through the narrow neck of the bottle. The consequence of this arrangement is that internal resistance is very low and the current very powerful for the first moment, but the small quantity of acid between carbon and zinc gets used up rapidly, and the strength of currents drops therefore 50 to 75 per cent. within the first minutes. If, however, the space between carbon and zinc admits *a sufficient quantity of acid*, bichromate cells may heat a cautery burner even for hours constantly.

electrician's help. They are portable, as far as this is possible for a battery of 23 lbs. weight filled with acid. Plates of india-rubber, floating on the surface of the acid, as well as properly constructed vessels, prevent spilling and evaporation. The zincs in bichromate batteries should be well amalgamated, and for this reason the zincs in our batteries consist of an alloy of 10 parts of zinc and 1 part of mercury, and, moreover, the acid contains some mercury too. The zinc plates last from two to five years, according to their use, and can be replaced easily without tools. It is necessary to clean and refill the bichromate batteries once in three to six months, according to their size and use, but it is very important to remove at least once in every six months the crystals adhering to carbons, zincs, and especially to the acid vessel. The quality of the acid is also of great importance for these batteries, as the strength of current depends very much on it. We recommend the following solution: *Dissolve* 1 lb. of bichromate of potassium in 8 lbs. of hot water, add *slowly* 2½ lbs. of strong sulphuric acid, while stirring constantly and dissolve in this mixture, while it is hot, 3 ozs. of bisulphate of mercury.

Dry Leclanche Cells.—One kind of Leclanché cell has so small an internal resistance that it can be used for *small* cautery operations. Six elements of 4 by 4 by 7 inches, three of which are connected parallel, and the two groups in series, are able to keep a burner requiring up to 12 ampères incandescent for about two hours altogether—not continually, as the battery requires some rest for recovering; but constantly for about five minutes at a time. These batteries are not to be recommended for regular use in the consulting room of a busy throat specialist, but they are convenient for eye and ear specialists, who require small burners only. They are suitable for portable batteries on account of the absence of any liquid.

The disadvantage of these batteries is that, after nine to twelve months' time, the current gets too weak for cautery, *whether the battery has been used or not*, on account of the gradual increase of the internal resistance. The cells will then still do for surgical lamps, bells, &c.; they cannot, however, be refilled, but have to be replaced by new cells which can easily be put in the battery boxes.

Rheostats for Batteries.—A rheostat is most convenient with every battery for regulating the strength of current for cautery. A bichromate battery, without a rheostat, cannot be plunged in deeper than is necessary for just making the wire red hot; on account of polarisation, etc., the current diminishes pretty quickly, and the battery ought to be gradually immersed deeper, in order to keep the burner at the same temperature; this would necessitate frequent attention to the battery. A rheostat, however, enables you to immerse the battery completely from the beginning, and to reduce the current to the proper dimensions by inserting an artificial resistance. As the cells have a larger surface by the deeper immersion, the strength of current remains constant for a much longer time, so that the operator can give his whole attention to the patient. Rheostats are quite indispensable for accumulators, as without them all burners would be destroyed at once.

Rheostats for cautery cannot be made with thin wire, as such wire would get incandescent too; hence for a current of 10 to 15 ampères, we

employ German silver wire of 2 to 3 mm. diameter, and about 6 ohms total resistance. This wire is wound in a spiral, and a longer or shorter piece of it can be inserted, by means of a sliding spring. It is best to begin by inserting the whole resistance, and after the circuit has been closed, to diminish it gradually, by moving the spring, until the platinum has the proper temperature for operations. A bright red or yellow heat is best ; white heat, or dark red heat, causes bleeding.

Galvanometers.—Galvanometers are not necessary for cautery, for it is not important to know how many ampères are required for obtaining the proper temperature of the platinum. They are convenient only for controlling the battery and for experiments.

Cords.—Connecting cords for cautery ought to be thick, because, if thin, they would either get too warm, or else weaken the current considerably. Their resistance should not be more than 0·02 ohm.

Handles.—There exist many different shapes of handles for holding the burners. All of them are fitted with a trigger, mostly like the trigger of a pistol, in order to enable the operator to introduce the platinum wires cold, and to heat them at the desired moment only, by closing the circuit through a pressure on the contact. Many handles have an arrangement for drawing a wire loop together, for the removal of polypi, tumours, etc., with the incandescent platinum or steel loop.

Burners.—The platinum burners which are made pointed, knife, cup, or ball shaped, are soldered on to copper wires of different lengths and curves, according to whether they are meant to be used in the nose, larynx, mouth, ear, etc. The copper wires are partly insulated from one another with silk, which is wound round them in the shape of an 8, but where the copper touches the platinum they grow so warm that the silk would get black, and therefore, they are for a short distance insulated with shellac varnish only.

Faults.—In order to rectify any fault, it is necessary with these batteries too, to find the seat of the defect, and it will then be easy to remove it. The burners are apt to fail because the two copper wires may touch at the end near the platinum, so that the current can pass directly from one copper wire into the other without reaching the platinum at all. This is a frequent fault, and can be recognised by the copper wires getting very hot. They should be separated with a finger nail so far that you can see between them all along. If the platinum of a burner has been fused by too strong a current, a new platinum wire must be soldered on with silver by the electrician. If the battery fails, in spite of the burner being all right, you should take off the handle, and let the two ends of the connecting cords touch each other. If they yield a strong, crackling spark, the fault is in the handle—the place of contact is oxidised, and has to be cleaned with fine emery paper ; but if the connecting cords yield but a weak spark, or none at all, the fault lies

further back. A weak spark shows that the connections, etc., are in good order, but that the battery is too weak. With bichromate batteries, this fault can be easily removed. If the solution has turned green, it is exhausted, and the battery must be cleaned and refilled. If the fluid is still red or brown, a cell has been short circuited by carbon and zinc touching one another, *or else the zincs are covered with a coating of oxide*, which can be best removed if they are screwed off and cleaned under a water tap with an old nail brush, until the bright zinc reappears. If there is no spark at all, although the battery can hardly be exhausted, you should remove the connecting cords and see whether the cells yield a spark, if the end terminals are connected with a short wire ; if this gives a spark, the rheostat or the cords are at fault. A fault in the cords is indicated by excessive flexibility on the broken place. A rheostat may get burned through under unfavourable circumstances—both faults have to be remedied by the electrician. If, however, there is no spark, either the connection amongst the cells is at fault, or the arrangement of the cells is incomplete ; which shows, if each element is tested singly at first, and afterwards groups of two or more cells ; or the battery is exhausted, and you have to clean and re-charge it as already stated.

For apparatus required to control the current supplied for lighting houses for cautery or spark coils, see pages 50—53.

ACCUMULATORS.

The Advantages and Disadvantages of Accumulators or Secondary Batteries compared with primary galvanic cells are as follows. Their E.M.F. (2 volts) is higher and their internal resistance lower (0·01 ohm to 0·1 ohm) than in all other cells, and for this reason they produce a remarkably powerful current, which, being completely depolarized, is perfectly constant until the accumulator is nearly exhausted. The acid is not used up, and therefore has not to be renewed except to make up for the loss by evaporation. Accumulators are specially suitable for spark coils, as strong currents are frequently required for a considerable time to work them. They are, moreover, convenient for running motors, heating cautery burners and small surgical lamps.

Their Disadvantages are, that they require a more scientific and careful treatment, more frequent attention, and more time for being recharged than primary batteries do ; that they are more easily damaged and that for repairs they have to be returned to the manufacturer.

They consist of lead plates immersed in diluted sulphuric acid. 136 volumns of *pure* strong sulphuric acid are mixed with 1,000 volumes of distilled water. The mixture ought to have a specific gravity of 1·15, or 36 Beaumé.

Chemical Process.—The sulphuric acid causes a thin layer of lead to change into sulphate of lead. An electrical current sent through such a cell produces electrolysis ; oxygen appears on the plates connected with the + pole, and converts the sulphate of lead into peroxide of lead. On the plates connected with the negative pole, hydrogen appears, and reduces the sulphate of lead into a porous, spongy mass of metallic lead. If the action of the current lasts long enough, the plates connected with the positive pole get converted entirely into peroxide of lead, and the negative plates into spongy metallic lead. Oxygen and hydrogen, finding nothing left to act upon, escape as gas, and it would be waste to let the current act any longer.

In this way, chemical changes have been effected by means of an electrical current. We have two different plates now, and the chemical action of the acid produces an E.M.F. If the plates are connected by means of a conductor, an electrical current is started *in opposite direction* of the charging current. During the discharge, the chemical process gets reversed ; the plates which had been covered with oxygen during charging get, during the discharge, covered with hydrogen, which combines with the oxygen contained in the peroxide, and produces sulphate of lead. The oxygen generated on the negative plates combines with the acid and changes the metallic lead also into sulphate of lead. As soon as both plates have returned to their original condition, all difference between them has ceased to exist, the E.M.F. stops, and with it the discharging current. The acid too has got back its original strength, and thus the process can be repeated any number of times.

The only difference between primary cells and accumulators is, that primary cells have to be charged with chemicals which have to be prepared beforehand, and which, when used up, have to be removed and replaced by a fresh supply. In the accumulators, it is the action of an electrical current which generates the chemicals required to produce the E.M.F., and a current will regenerate them as often as desired, without a renewal of acid.

Capacity.—The capacity of the accumulators, *i.e.*, the quantity of electrical energy which they can store, in form of chemicals, is in direct proportion to the quantity of lead which they contain. Moreover, the current by which an accumulator is charged or discharged, has to be in proportion to its capacity. If the density of current (the number of milliampères per square centimetre) is too great, the oxygen cannot change the sulphate quickly enough, and therefore part of it escapes as gas unutilized. In discharging too heavy a current, the cell will become polarised in consequence of the same difficulty. There is no fixed rule how many ampères may be used for charging or discharging accumulators, this depends in the first instance on the capacity of the accumulators, and, secondly, on the special construction of the plates. As a general rule, the charging current ought not to exceed one-fifth, and the discharging current one-fourth of the capacity ; that is to say, a 20-ampère hour accumulator should be charged with not more than 4 ampères, and discharged with not more than 5 ampères. Some kinds are made specially so that they can stand a considerably higher rate of discharge. If the strength of the discharging current is exceeded, the efficiency decreases, and instead of 20, only 15 or 10 ampère hours will be obtained from the accumulator. In extreme cases, when an accumulator is short circuited, the plates are destroyed by crumbling up.

Charged Accumulators have the tendency to Discharge slowly without being connected with a conductor, in consequence of defects in

the insulation (as dampness, dirt, etc.), and also on account of impurities of the acid. (If these are considerable, especially if the acid contains a trace of arsenic, the accumulator cannot be charged at all.) Sulphate of lead is therefore gradually being formed even while the accumulators are standing unused. The sulphate, when freshly formed, is fine and soluble, and can be changed into peroxide by means of a current. After some time, however, it assumes a crystalline form, becomes insoluble, and cannot then be changed any more into peroxide by the current. The capacity of the accumulators decreases therefore in proportion to the increase of the sulphate of lead crystals. Plates which have become defective in this way are useless, and have to be replaced by new ones.

The following rules can be derived from the above statement:—

(1) The capacity of the cells must be in direct proportion to the discharging current. If, for instance, the accumulators are intended for working spark coils or cautery burners, they should be of a size which can discharge up to 15 ampères without becoming damaged. Cells which are too small for the work required of them, will soon be destroyed.

(2) Short circuit must be avoided. Terminals must not be connected with a wire in order to see a spark, as it tends to destroy the plates. The connecting cords should be attached to the spark coil or cautery handle *before* the other ends are connected with the accumulator terminals.

(3) In charging, the + pole of the charging current has to be connected with the + pole of the accumulator. The latter is usually painted red. If by mistake the wrong poles are connected, the accumulators discharge rapidly and are destroyed.

(4) Accumulators must be re-charged frequently, *whether used or not*. If this is neglected their capacity is diminished, on account of the formation of insoluble sulphate of lead. This explains why accumulators give every satisfaction when used in lighting stations, where they are re-charged daily, or at least once a week, but many medical men are under the false impression that the accumulators need no re-charging so long as they still yield a current. The smaller the accumulators, the more frequently have they to be re-charged.* Accumulators of 20-ampère hour capacity and more, ought to be re-charged at least once a month to keep them in good condition.

The Charging of the Accumulators is best done by dynamos. Where the *continuous* current is laid on for illuminating purposes, medical men can easily do it themselves. One or several incandescent lamps are inserted in the circuit. By means of pole-finding paper, the polarity is ascertained (the negative pole

* The so-called pocket accumulators with a capacity of less than 10 ampère hours, may give satisfaction to those doctors who regard them as a hobby, and charge them frequently enough from their own lighting installation, but in every other case they are sure to be failures. A proof of this—quite independent of our own experience—is the fact that, about two years ago, a London Omnibus company provided their ticket controllers with pocket accumulators and electrical bull's-eye lamps. A special shed was erected for a charging station in the yard of Victoria Station which shows that no money was spared to work them under proper conditions, but, nevertheless, the lamps, accumulators, and charging station disappeared after a year's trial.

makes a red stain on the moist paper), and the charging is continued till gas bubbles appear, the acid turns milky and makes a hissing noise. A 20-ampère hour accumulator will take about twenty hours for charging with a 32 candle-power lamp in a 100-volt circuit. If four lamps of this same candle power are connected parallel, the charging will be finished in five hours.

It is possible to charge accumulators from primary batteries. The so-called gravity cells (copper-zinc without a porous pot) are best suited for the purpose. These cells have nearly 0·9 volt each, and as towards the end of the charging the E.M F. of the accumulators rises to nearly 2·5 volts, four of these cells should always be connected in series for each single accumulator cell. If only four cells are used to charge a 20-ampère hour accumulator, the charging will take about 170 hours. If, however, you take twelve cells, and connect each three parallel, and the four groups in series, the charging will be done in about 55 hours. Cells like these can remain permanently connected with the accumulators, but some vitriol of copper should be added to each cell once or twice a week. There should also be a galvanometer in the circuit to measure the strength of the charging current and control its direction.

Thermopyles may also be used for charging accumulators ; it will, however, be more advantageous to use large bichromate cells instead of the accumulators in most of the cases where a current from a dynamo is not available for charging.

The plates *must be fully covered by the acid*, and if the latter has partly evaporated on account of too prolonged charging, or for some other reason, it has to be brought to its original level by some fresh acid.

A Voltmeter is very convenient for controlling accumulators. While in good condition, each cell gives fully 2 volts. If the E.M.F. falls to 1·8 volts per cell the charge is nearly exhausted, *and the accumulator should be re-charged at once.*

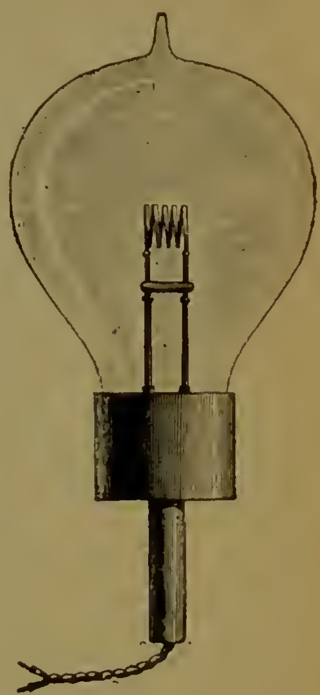
During discharging, accumulators may be connected parallel, but while charging this should be avoided. Six 20-ampère hour accumulators connected in series give 12 volts, and, say, 5 ampères for 4 hours. The same battery connected so that two cells are parallel and the three groups in series, will give 6 volts and, say 10 amperès for 4 hours.

Many attempts have been made to produce dry accumulators, but up to now they have been a failure.

BATTERIES AND INSTRUMENTS FOR ELECTRIC LIGHT.

Advantages of the Electric Light.—The electric light is whiter and more intense than any other kind of light. It develops less heat, and the lamps need not be held upright, as oil lamps, for instance, and can, therefore, be brought much closer to the object which has to be examined. All these facts help to make incandescent lamps most useful for medical purposes, in the consulting room, but more especially in the patient's house, where often a wax candle is the only other available light which might be used. The electric light is, moreover, the only kind of light which can be introduced into the human body,

either for examinations of cavities like the bladder, or else to discover bleeding arteries during operations, or to make part of the body transparent (antrum) for diagnostic purposes. It is, moreover, a most convenient night light for medical men, who are often called out at night; for a turn of the switch, which may be fixed on the bedstead, is sufficient to light up the whole room. Finally, it is useful as a reading lamp in carriages, for invalids, etc., although in these latter instances, the fact that the electric light produced by batteries costs still about 3d. to 5d. an hour for a 2½-candle lamp is a disadvantage. In houses where the electric light is laid on, lamps of 32 to 100 candle power may be used with the concave mirror for examining throat, nose, eye, etc. Special lamps are made, the carbon filament of which is not horse-shoe shaped, but fitted in the centre of the lamp, so that the lamp can very well be used with a lens. These lamps give a good light of 25 to 100 candle-power, according to the lamp chosen. If properly arranged, the lamps do not show light and dark spots, and as to convenience and cleanliness, they are superior to any other lamp.



Resistance of the Lamps, and Strength of Current required.—The resistance of the incandescent lamps used for medical purposes varies from 7 to 25 ohms. The strength of current required for rendering the carbon filaments of the usual lamps incandescent is 0·5 to 1·6 ampère; 1 ampère is about the average. The longer and thinner the carbon filament, the more resistance it has, and the less current is wanted to bring it to white heat, and *vice versa*. Lamps requiring 0·75 ampère, or less, remain so cool that they can always be touched. Lamps which require 1 ampère and more, however, grow pretty warm if they burn in the open air. In order to obtain this strength of current with the resistances mentioned before, 8 to 12 volts are required, and therefore batteries of four to eight cells, connected in series, are necessary, according to the E.M.F. and the internal resistance of the cells.

The carbon filaments have a much higher resistance than the platinum burners used for cautery, but require considerably less current to become incandescent; but all cautery batteries with four and more cells can very well be used for surgical lamps too. Most of the lamps require, however, more milliampères than the small portable cells, constructed for galvanisation and electrolysis, are able to keep up for any length of time. These batteries of many small cells

certainly make the lamps incandescent, but they polarise too quickly with a current of 750 milliampères, and consequently the light is not constant, but diminishes after a very short time; only the large Leclanché cells used for office batteries depolarise quickly enough to give a steady light for some minutes at least with these lamps. The cells for batteries for the electric light ought to be larger than the cells for galvanisation, but they need not be as large as the cells for cautery; the larger they are, the longer they will be able to keep a lamp incandescent, and the more cells there are, the longer may the carbon filament be. The *number* of cells does *not* influence the *time* a battery can keep a lamp incandescent; a 6-cell battery keeps a lamp burning for the same time as a 10-cell battery, provided that both are fitted with the same kind of cells.

What are the most suitable Cells?—The variety of cells for producing light is not very great, because no cells with high internal resistance can be used, and because nearly all the batteries have to be portable.

Bichromate Cells.—Bichromate batteries (about their treatment, mixing the solution, etc., see page 26), *provided that the cells are not made too small*, are constant enough, and quite apart from their high E.M.F. and great strength of current, they have the great advantage that the owner is independent of the electrician for some years at least, as he can keep them in order himself, an important point for doctors, who live far from the manufacturer. They have, however, to be refilled every three or four months, and as far as convenience and cleanliness go, they have certainly been surpassed by other batteries, suitable for doctors living within reach of the manufacturer.

Accumulators.—Are very suitable for surgical lamps, they are described on pages 28—31.

Leclanché Dry Cells.—Have an E.M.F. of 1·5 volt, and an internal resistance of 0·3 ohm. They are small enough to be very portable, and as they contain no liquid they can be sent charged as ordinary luggage all over the world. They are, owing to their peculiar construction, more constant than fluid elements of the same size. The dry cells, if exhausted, can still be used for house bells, &c., but they cannot be refilled. These batteries are the only ones which are really reliable for fifteen to eighteen months, *without requiring re-charging or any other attention during this time*, and are, therefore, more convenient than bichromate batteries or accumulators; but the cells have to be replaced by new ones—*even if the battery has not been used*—after about one-and-a-half years. New cells have to be bought, but these can easily be put in place of the old ones, so that the battery itself need not be returned to the maker.

If the battery need not be portable, fluid Leclanché cells are very suitable for incandescent lamps ; but *large* cells must be used, at least for lamps requiring one ampère. As to the refilling of liquid Leclanché cells, see page 11.

For **Transformers and Rheostats** for utilizing the 100 to 250 volt currents from dynamos for small surgical lamps, see pages 44—54.

Rheostats are not absolutely necessary for surgical lamps, but they are most convenient, and the small expense of obtaining one will be made up in a short time, because fewer lamps will be destroyed by using them. The rheostat had best be fixed on the battery, as in this way it may be used for several instruments. Rheostats for surgical lamps ought to have a total resistance of about 30 ohms, which can be inserted gradually. They are best made of German silver wire, which ought to be thick enough to allow a current of 2 ampère to pass without getting hot.

Galvanometers are not necessary, as a bright light only is required, and there is no need for knowing how many ampères are wanted for each lamp. The cords need not be as thick and heavy as those used for cautery, and as the difference between the positive and negative poles is of no consequence in this case, they are generally so twisted, that there seems to be only one cord leading from the battery to the instrument.

Normal rate of Burning.—The amount of light which a lamp can yield may not be increased to any extent by increasing the strength of current, without damaging the lamp. The carbon filament should be a little more than yellow. If this degree of incandescence is exceeded, the lamp can certainly give twice as much light than under ordinary circumstances, but its life gets considerably shortened, as the carbon filament evaporates by being over-heated. If the current used is very much in excess of what the lamp requires for becoming white hot, the lamp will stand it but for a few minutes, or give only one momentary flash. If the current which the lamp requires is not known, the whole resistance of the rheostat should be inserted, and the current can then be increased by diminishing the resistance, until white heat is obtained. The life of small surgical lamps varies between twenty and one hundred lighting hours with ordinary use, and the candle power is equal to one to five candles.

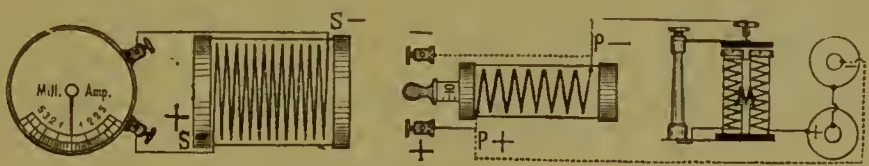
Faults.—If the instrument fails, examine first of all the lamp. The lamps are provided with an arrangement allowing them to be exchanged easily—in most cases they are fitted with a screw, *which has to be well screwed home.* The lamps may get loosened by shaking, heating, etc., when the light fails this ought to be seen to first. The carbon filament may be burned through, and this frequently shows itself by the glass looking grey. In this case the lamp has to be replaced by a new one. But if the lamp and its connection with the instrument are in good order, and still there is no light, the fault

is likely to be in the battery, and may be found out in the way mentioned already under galvanic cautery; for experience shows that, with the exception of the lamps, the illuminating instrument itself is hardly ever in want of repair. The sparks obtained from batteries for the electric light are not nearly as strong as those yielded by the cautery batteries, and therefore it requires more attention, especially in daylight, to find out whether the battery gives a spark or not. With plunge batteries, the fault may be easily set right, but accumulators have to go back to the electrician. For Leclanché dry batteries new cells have to be bought, but they can easily be put in place of the old ones and reconnected, so that there is no need of sending the batteries back.

FARADISATION.

The genius of Faraday taught the world another way of producing electricity. He found out that in a closed circuit a current is induced as often as a magnet is approached to this conductor, or withdrawn from it, or as often as a current is closed or interrupted in the neighbourhood of the closed circuit. This discovery was the first step towards producing electricity by mechanical power—towards the dynamo, telephone, and all the marvellous acquisitions of the last thirty years.

Origin of the Induced Currents.—If the two ends of a wire are connected with a sensitive galvanometer, and a magnet is approached to the wire, the needle of the galvanometer declines *as long as the magnet is approaching*, and returns to 0 if we cease to change the distance between wire and magnet. If we *withdraw* the magnet, the needle declines again, *but in the opposite direction.* If in the neighbourhood of the closed conductor a second wire is drawn parallel to the first one, and the ends of



this second wire are connected with a galvanic cell, the needle deflects the moment the circuit is closed, although there is no connection whatever between the two wires; but it returns to 0 immediately afterwards, and remains there, although the galvanic current continues to circulate in the second wire. If we diminish or interrupt the current, the needle deflects again, but in the opposite direction. This shows that the approaching and the withdrawing of a magnet, or the making and the

breaking of a current in a conductor close by, induces currents in a closed circuit, which, however, are of very short duration only, and which pass in opposite directions.

Alternating Currents.—The currents induced by *closing* a galvanic current pass in the direction *opposite* to that of the inducing current; the currents induced by *breaking* the inducing current pass in the *same* direction as the inducing current. If we make and break the inducing current very often consecutively, we induce each time a momentary current in another conductor; but the directions of these induced currents keep changing, and for this reason we call them *alternating* currents, in contrast to those currents which keep their polarity.

Wagner's Hammer.—Wagner's hammer (see diagram, p. 40) is most frequently used for rapidly making and breaking the current. The current passes through the electro-magnet, through the hammer, the contact screw, and back to the battery; or else it can be made to pass from the contact screw through the inducing wire and then back to the battery. As soon as this arrangement is connected with a cell, the electro-magnet becomes magnetic and attracts the hammer, which consequently leaves the platinum point of the contact screw. This, however, interrupts the current, the electro-magnet ceases to be magnetic, and a spring causes the hammer to fly back; as soon as it touches the platinum point again, the current is closed once more and the hammer attracted, and this play lasts as long as the apparatus is connected with a cell giving a current. The wire through which the inducing current passes is called the *primary* wire, and the wire in which currents are induced is called the *secondary* wire; the induced current is called the *secondary* current.

Self-Induction. Extra Currents.—For various reasons we do not draw the primary and secondary wires in a straight line, but wind them in spirals on cylinders of wood, paper, etc., which are made of such sizes that the primary coil can be pushed into the secondary coil. In a spiral each turn of the wire is parallel with the previous and following turns of the same spiral, and a current which passes through a turn of the spiral must have, therefore, an inducing influence too on the other turns close by. This effect of the different turns of the same spiral on one another is called *self-induction*, and the current thus induced is called the *extra current*. If the current is made, the extra current, too, has an opposite direction to the inducing current, and thereby *retards and weakens* the inducing current, and consequently the secondary current, too; but if the inducing current is interrupted, the extra current flows in the *same direction* as the inducing current, and *increases* thereby the latter current very considerably, and consequently the secondary current, too. The shocks which are induced by making and breaking the inducing current are, therefore, of very unequal strength; those induced by breaking the inducing current predominate very much, and the signs + and − which

are near the terminals of the better induction coils are intended to show the direction of the currents induced by *breaking* the inducing current. The signs would have no meaning if the currents induced by making and breaking the inducing current had an equal strength, as they follow one another in opposite directions.

Primary Currents.—If we connect one or two galvanic cells with a Wagner's hammer, which is provided with a small electro-magnet only, and connect the cells by means of two further wires with two electrodes, which we hold in our hands, we shall not feel the making or breaking of the current. But if the current has to pass a primary coil with several hundred turns of wire besides the Wagner's hammer, each breaking of the current gives us a decided shock, the strength of which, amongst other things, depends upon the number of turns of the coil ; this shock is caused by the extra current. This is the *primary* current, which we obtain from medical induction apparatus ; it is an *intermittent galvanic current*, very considerably increased by the extra current, but it is *not an alternating current.* We shall come back to a further difference between primary and secondary currents later on.

Iron Core.—The inducing effect of a current is considerably increased by letting it act simultaneously with a magnet, and this can be arranged easily if the primary wire is wound round an iron core, or better, if it is wound round a cylinder into which an iron core can be pushed. It is, however, preferable, that the iron core should consist of a bundle of soft iron wires, as these take and lose magnetism much quicker than solid iron. In this way two powers act inducing in the same direction and exactly at the same time, the making and breaking of the inducing current, and the sudden appearance and disappearance of a strong magnet.

E.M.F. of the Induced Current.—The E.M.F. of the induced current depends on the number of turns of wire which a coil has ; the more turns the higher the E.M.F. (2), on the strength of the inducing currents ; the stronger the latter, the higher the E.M.F. of the induced currents. (3), on the presence or absence of an electro-magnet ; its presence increases the E.M.F. of the induced current very materially. (4), on the suddenness of the break of the inducing current. Ultimately the E.M.F. of the secondary current depends on the distance between the secondary and primary coils ; the closer they are together, the higher is the E.M.F., and *vice versa.*

Strength of the Induced Current.—The strength of the induced current depends too on Ohm's law. If, for instance, an induced current has 70 volts, and the resistance of the secondary coil is 610 ohms, and the resistance of the patient 2,300 ohms, the strength of the current would be

$$\frac{70 \text{ volts}}{610 + 2{,}300 \text{ ohms}} = 0{\cdot}024 \text{ ampères} = 24 \text{ milliampères.}$$

Measuring the strength of Induced Currents.—The strength of the induced currents cannot be measured with an ordinary galvanometer, partly because the secondary current is alternating, and would, therefore, make the needle deflect one moment to the right, and the next moment, to the left. There are certainly some galvanometers without permanent magnets, which might be used, but the chief obstacle is that the currents are intermittent, *i.e.*, as the shocks last but a very short time, the galvanometer remains for a time without any current, until a second impulse occurs. If the interruptions follow one another very quickly, such a galvanometer would indicate more current than if the interruptions were slow, although in both cases the strength of current would be exactly the same. The only possibility for measuring medical induction currents in absolute units consists in measuring their E.M.F., and later on we shall describe an apparatus for this purpose.

Chemical Action and Mechanical Effect of the Induced Current.—The chemical action of faradic currents is small, principally on account of their very short duration, and moreover because they are alternating, so that each following impulse in the secondary current neutralises partly the effect of the preceding impulse. The mechanical effect of these suddenly appearing and disappearing currents on the human body, however, is very intense. If we place electrodes on the body, the muscles contract each time the current is made, and much more so when it is broken, so that the muscles can be excited with these currents to a great extent.

Differences in the Effects produced by Primary and Secondary Currents.—The effect produced by the secondary current depends a great deal on the diameter of the wire which is used. Very fine wires (0·1 millimetre, or finer) produce a pricking local pain, but not very strong muscular contractions; if we increase the diameter of the wire, the contractions get more powerful; if the secondary coils are wound with thick wire (No. 18 to 22 B.W.G.) they produce exactly the same effects as a primary current, *i.e.*, less local pain, but powerful contractions of the muscles near the electrodes, or even in the whole body. The primary, or the secondary current produced in a coil with thick wire, is frequently applied if the deeper lying organs, such as, for instance, the bowels, etc., are to be treated, whereas the secondary current produced by a coil with fine wire is chiefly used for the treatment of muscles and nerves which are near to the skin. This is the practical difference between primary and secondary currents. It is no doubt only due to the great difference in the resistance of the coils and in the E.M.F., but it is impossible to draw a sharp line between them, and to define accurately in what cases the one, and in what cases the other should be applied. For the electric bath the primary current, or a secondary coil with thick wire only can be used.

Construction of Medical Coils.—The shape and external appear-

ance of the coils used for medical purposes vary very much, but still (if we except the magneto-electric machines, which, on account of several deficiencies, are rarely used now) they are all constructed on the same principle. The primary coils have between 100 and 600 turns of wire. The resistance of the primary coils is made small, 5 to 15 ohms, so that one or two cells can produce a strong current in them already, and the diameter of the wire ought, therefore, not to be too small. Insulated copper wire, No. 22 B.W.G., is mostly used for the primary coils. The E.M.F. of the primary current varies under these circumstances between 5 and 30 volts, according to the number of turns, and according to whether the iron core is drawn out or pushed home.

How to Regulate the Primary Currents.—The E.M.F. of the primary current can be regulated in different ways; for instance, by inserting a larger or smaller number of turns of wire by means of a crank, etc. The simplest and almost only method practically used, however, is to regulate the E.M.F. by pushing the iron core in and out. The primary current is weakest if the iron core is drawn out, and gets stronger the more it is pushed in. Instead of drawing the iron core out, a damper in the shape of a brass or copper tube can be slipped over it with the same effect. If the iron core is entirely covered with the tube, its inducing power ceases to act, but the E.M.F. increases the more the brass tube is withdrawn. The position of the secondary coil has *no* influence on the strength of the *primary* current.

How to Regulate the Secondary Current.—The secondary coil is generally constructed with a large number of turns of wire, about 2,000 to 6,000 turns, for in most cases it is desired to obtain a high E.M.F. The wire used for it is generally thin copper wire, about No. 36 B.W.G. The resistance of the secondary coil varies under these circumstances between 100 and 900 ohms, and the E.M.F. between 10 and about 200 volts. The strength of the secondary current can be regulated in

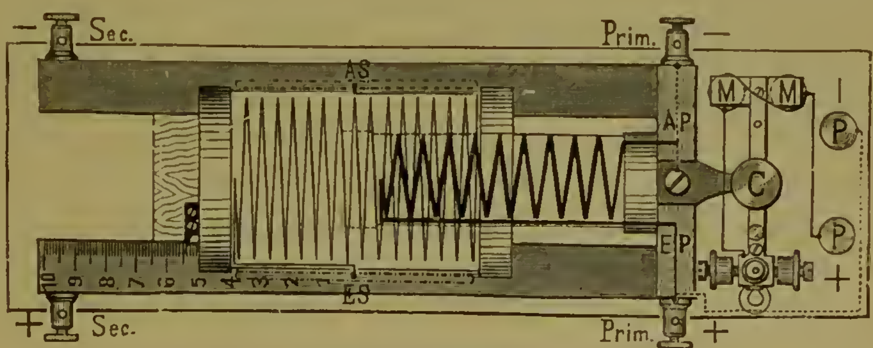


Fig. 19.

different ways. If the apparatus has a small primary coil, it is sufficient for all purposes of treatment to regulate the strength of the secondary current, merely by pushing the iron core in and out, for a current which is hardly to be felt when the iron core is drawn out can be

increased quite gradually to painful strength by pushing it home. The more complete coils, however, are so arranged, that the distance between the primary and secondary coil can be easily changed. In this case the secondary coil slides on a sledge, and can be pushed over the primary coil, or be drawn away from it, an arrangement which allows an exceedingly fine regulation of the current. These sledge coils, which were first suggested by Dubois Reymond, are decidedly preferable to any other coils for diagnostic, and for physiological purposes. The strength of current in this apparatus can be further regulated by pushing the iron core in and out. The secondary current might also be regulated by means of a crank which inserts more or less turns of wire, but this does not allow as fine graduations as the moving of the iron core or the coils; —or it might be regulated with rheostats; but this is not very practical and is seldom used as high resistances would be required.

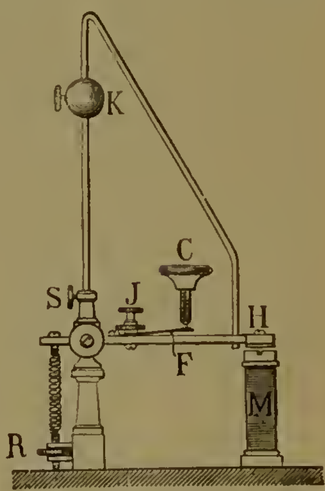


Fig. 20.

Rapidity of Interruptions.—The Wagner hammer of an induction apparatus can be regulated within certain limits, so that the interruptions follow one another slower or quicker. The sooner the hammer meets the platinum point again after having been drawn away from the electro-magnet by the force of a spring, the sooner the current is closed, and the hammer attracted again. The further we screw this contact screw home the quicker will be the vibrations; but if we screw it too tightly, the hammer has no room for moving any more, and ceases to work. The more we unscrew the contact screw, the slower will the interruptions follow one another, but we must not unscrew it too far, as the hammer must make good contact with the platinum point in flying back, else it would also cease to vibrate. The power of the spring, as well as the strength of the inducing current, have, however, something to do with the rapidity of the interruptions. In order to make the interruptions even slower, the hammer can be lengthened with a bar, on which an aluminium ball can be raised or lowered. The longer this pendulum is, the slower are the interruptions; they can be reduced to twenty or even less per minute. A few apparatus are fitted with a clock work, which can be made to run at any speed, and the interruptions produced per minute are accurately registered by the clock work. Slow interruptions produce more powerful and painful contractions than quick ones. If the number of interruptions is very great, anæsthesia can be produced, and special apparatus have been made for obtaining this result.

What are the most suitable Elements? Bichromate Cells.—Various kinds of elements may be used for working medical coils; we will begin with the bichromate cell. We have already mentioned its

advantages, *i.e.*, its high E.M.F., small internal resistance, and, more especially, the fact that it can be easily kept in order without technical help, and these qualities, added to its small size and cheapness, render it very suitable for the majority of medical coils. One cell is sufficient for supplying a strong inducing current. The vessels for the elements are best made of strong glass, as all ebonite vessels leak after a time. The cells are closed with india-rubber stoppers to prevent spilling in carrying the apparatus. The acid consists of 1 oz. bichromate of potassium, dissolved in 10 ozs. of water to which are added 2½ ozs. strong sulphuric acid, and ½ oz. bisulphate of mercury. As the acid does not decompose, it is best to mix about a pint at a time. If the acid turns green, the cells should be emptied, rinsed out and re-filled with fresh solution. With most of the portable apparatus one charge of the cell suffices to keep the hammer going for about two hours. The fact that acid cells are troublesome on account of the frequent re-charging and the inconstancy of the cells, has been the cause that other cells have come into use for working the coils as well.

Leclanché Cells.—Large Leclanché cells are also very well suited for working coils, and are used for them in all office batteries.

Dry Cells.—Leclanché dry cells are so very well suited for portable induction coils, that they supersede all other cells for this purpose. They are much more constant than the acid cells, but the chief advantage is that they contain no acid to spill and corrode the coil, clothes, etc. It is no exaggeration to say, that under 100 cases in which coils went out of order and required repairs, it was 99 times due to the spilling and evaporation of acid. We have sold many hundred coils with dry cells during the last eight years, and *none of them* has come back for any other purpose except the renewal of the cells. An Obach R. cell, measuring 1¾ × 1¾ × 4½ inches, will work for instance a Spamer coil for 30 to 70 hours (according to whether the iron core is withdrawn or pushed home) and when exhausted, it costs 2s. 6d. to replace this cell by a new one. The acid and zinc required for working the same coil for a similar length of time would cost more,—not reckoning the damage done by the acid to the coil, the temper, clothes, etc. After long experience with these cells in our coils, we would cease to make coils with acid cells altogether if the latter had not still some advantage for the Colonies and out-of-the-way places, where the dry cells cannot so easily be replaced. New dry cells can easily be put in the place of the old ones without returning the coil to the maker.

Thermopiles.—If an apparatus need not be portable, or if experiments have to be made where absolute constancy of the inducing current, even for years, is of importance, thermopiles are most suitable, as their E.M.F. changes less than the E.M.F. of any other source of electricity. They are started by lighting a small gas, oil, or spirit flame They are convenient and reliable for all induction coils which have not

to be portable, and they are not likely to require repair, unless they get damaged by a fall or some such misadventure.

Faults.—If an induction coil fails, you should see first whether the element is exhausted. Acid cells require refilling about once in a fortnight, if the apparatus is in daily use. If you are sure that the cell is all right and gives the necessary current, you should see whether the interrupter is in order. The interrupter is the most delicate part of the induction coil, and therefore you should be careful not to interfere with the contact screw if it is not strictly necessary; for very often apparatus which were in quite good order have been spoiled by playing with this screw. The interrupter does not always start of its own account, and has to be put in vibration by being slightly touched with a finger. The hammer should be arranged so that its distance from the electro-magnet is about the $\frac{1}{16}$th part of an inch, and the platinum point of the contact screw should just touch it. Those apparatus in which the hammer is fastened to a rigid bar, as in Nos. 6, 6A, 7, 8, 16, and all sledge coils, are less liable to get out of order and to require readjustment than those coils the hammer of which is attached to a watch spring, as coils 1 to 5, 9 and 14. The interruptions of these latter apparatus are also frequently less regular. If an interrupter has not the proper distance from the electro-magnet, it has to be carefully bent, till it keeps the proper distance. The spark on the interrupter attracts dust, and the little platinum sheet should be cleaned occasionally with fine emery paper. Oil should on no account be allowed on the interrupter.

If the apparatus fails, although cell and interrupter are in order, *see whether the connecting cords* are in order. We should like to repeat here, that it is of no use to test an apparatus by touching the terminals or the connecting cords with two fingers. An apparatus can only be tested with well soaked and properly connected electrodes. The coil and the connections are very well protected, and can be damaged only by spilling a good deal of acid; the connections get oxidised in such a case, or the wires may even be eaten through. An apparatus damaged in this way has to be sent back to the manufacturer.

Faradimeter.—Before closing this chapter, we have yet to describe the apparatus with which it is possible to measure the faradic current. Experiments have shown that currents of very short duration produce the same physiological effects, whether they are produced by a galvanic battery, a condensator, or an induction coil. Based upon this experience, Drs. v. Ziemssen and Edelmann have constructed induction coils, the scales of which are not graduated in millimètres, but in volts. In order to get always exactly the same number of volts out of the secondary coil, with a given distance between the primary and secondary coil, it is necessary that the inducing current should be kept constant. For this purpose the apparatus is fitted with a rheostat and a galvanometer. By pressing a key, the inducing current may be sent through the galvanometer and a resistance, which is equal to the resistance of the primary coil, and further through a variable resistance, with which the strength of current can be regulated. When the key is opened the current passes through the varia-

ble resistance and the primary coil. In this way the strength of the inducing current can be conveniently ascertained and regulated. The number of volts marked on the scale along which the secondary coil slides is correct as long as the strength of the inducing current is exactly 300 milliampères. The scale is graduated from 5 volts to 200 volts. In this way the induced current can be measured in absolute units like the galvanic current.

FRANKLINISATION.

Static electricity is now used very frequently for nervous and hysterical diseases, sleeplessness, etc., in America, Austria, Germany, and especially in France, but in Great Britain it is yet seldom used. The reason for this is, no doubt, the climate, which is unfavourable for static machines here, but as there are now machines which can be started even in the dampest weather, a few words about them will not be amiss. As far as the origin of static electricity is concerned, and about the construction of the machines, we must refer to larger works on electricity. Static machines are considered by many physicists the most ingenious of all physicial instruments, and as the process is rather complicated, it seems to us useless to attempt to describe it in a few words only. The electricity yielded by static machines, is of a very high E.M.F. The number of volts can be estimated according to the length of the sparks.

For sparks of	0·18	0·7	5	15·6	18·8	mm. length,
have approximately	1000	2000	5000	12000	15000	volts.

Sparks of 100 millimètres' length being nothing uncommon with such machines, we may suppose that the tension amounts frequently to 100,000 volts and more. The strength of current, however, is exceedingly small, and the chemical effects are 0 for all practical purposes.

The manner of application is about as follows: For general franklinisation the patient is placed on an insulating chair, and connected with one pole of the machine for some twenty minutes. For local applications he is also mostly placed on the chair, and an electrode connected with the other pole is brought near the spot which is to be franklinised. If this electrode is fitted with a point, the so-called electrical wind appears, which, according to Charcot and Boudet, is specially valuable for neuralgic pains, etc. If the electrode is fitted with a ball, sparks appear, which are used to excite paralysed and unsensitive organs. With Morton's electrode the spot of application can be localised exactly, and with such an arrangement the sparks can also be applied internally.

According to different authors it seems to be of special importance with this kind of electricity, which pole is applied to the patient. According to them (for instance, Dr. Stein), the negative pole has a depressing influence on many patients, whereas the positive pole has an invigorating influence; and this seems to be in accordance with the fact,

that, under normal conditions, the air is always charged with positive electricity (of 100 days the air electricity is positive on about 95 days, and negative only on about 5), and only under abnormal conditions, during thunderstorms, or hail and heavy storms, etc., it changes to negative electricity. We must leave it to our readers to find out how far these statements are correct, but we will give a few hints which will make it possible to tell the negative pole from the positive one. In a dark room the poles can be easily distinguished. The pole on whose comb brushes of light appear, is charged with negative electricity, and the pole on whose comb points of light appear, is charged with positive electricity. If a burning candle is placed between the poles of a machine in action, the flame points towards the positive pole.

Static machines are turned either with the hand, or else, and this is much more convenient, with small motors. In towns where the electric light is laid on, these will mostly be electro-motors, but in other places they may be small water motors, gas motors, etc., or else electro-motors which are driven by batteries. About the treatment of these machines, we must refer to the directions for use sent with the different machines.

APPARATUS FOR UTILIZING CURRENTS FROM DYNAMOS FOR SURGICAL & MEDICAL PURPOSES.

The electrical current for lighting houses is nowadays available in so many places, and there is so much demand for apparatus which make it possible to utilize the current from dynamos for medical and surgical purposes, that we will describe them in a separate chapter.

The advantages of the Current from Dynamos are numerous. There is no necessity to produce electricity by means of corrosive chemicals; glass cells and the renewal of zincs and chemicals is not required, and there is no occasion to send the apparatus from time to time to the Electrician for cleaning or repair. Instead of this the current is supplied ready made. The current from dynamos is, moreover, cheaper than that produced by chemicals. The original expenses of the apparatus required for its regulation are not more, sometimes even less than the cost of batteries, and as there is no expenditure for refilling and repairing these apparatus, they are decidedly cheaper.

Reliability of the Apparatus.—In 1890, I was the first electrician who began to construct these apparatus, and though many hundred are now in daily use, no complaints of failures have reached us.

In consequence of these advantages batteries are replaced by these apparatus wherever the current from dynamos is available, and on

account of their simplicity and reliability many a medical man, who did not care to be troubled with batteries, will use the electrical current for surgical and medical purposes if he can obtain it from a dynamo.

There exist two kinds of current which may be used for lighting up houses, and the apparatus required for utilizing them differ considerably.

Continuous and Alternating Current.—In some districts they supply the continuous or low tension current, the E.M.F. of which varies between 100 and 250 volts. This kind of current suits every purpose for which electricity in medicine and surgery is required, *i.e.*, for galvanisation, electrolysis, faradisation, cautery, surgical lamps, running motors, exciting spark coils for Röntgen rays, and charging accumulators.

In other districts the current supplied is oscillating rapidly, and changes its direction or polarity many thousand times per minute. This is called the *alternating* current. Its advantage for the electric light companies lies in the cheaper distribution. The E.M.F. in the mains in the street is between 2,000 and 5,000 volts, and with so high an E.M.F. 50 times as much electricity can be sent through a conductor of given diameter than would be possible with an E.M.F. of only 100 volts. The cables can therefore be made much thinner, but the insulation has to be more efficient. When brought into a house, the alternating current passes through a transformer, which reduces this high E.M.F. to 100 volts, in a few cases to 200 volts. On account of the continuous reversal of direction this current *cannot* be used for galvanisation, electrolysis, or charging accumulators ; it is however, as we shall see later on, much more convenient than a continuous current for cautery, surgical lamps, and for sinusoidal faradisation, and it can also be used for driving motors.

It is impossible to use currents of 100 and more volts directly for medical purposes, Patients would receive severe shocks and dangerous currents if such a voltage were applied directly, and cautery burners or small surgical lamps would become instantly fused. For these reasons we require apparatus enabling us to control the currents.

Apparatus for Controlling the Continuous Current.—Resistances which would protect the patient from an overdose might be interposed between dynamo and patient or cautery burner in the circuit. According to Ohm's law a resistance of 100,000 ohms would reduce a 100-volt current to 0·001 ampère (1 milliampère) and a resistance of about 6 ohms would reduce the 100-volt current to suitable dimensions for a cautery burner of average size. This connection "in series" has, however, shown certain defects. Even a weak current of say 2 milliampères, which would not be felt at all if produced by a battery with a few volts, produced a peculiar burning sensation, the reason of which has not yet been fully explained. The consequence was, that patients could bear a stronger current from batteries than from dynamos. With cautery burners, surgical lamps, etc., the spark started by breaking the current was so powerful that it destroyed the contacts in cautery handles, etc., by

setting up an arc light between them. These drawbacks have caused us to try another method, *viz.*, by inserting the patient or cautery burner, etc., in a shunt circuit, instead of connecting them in series. This enables the operator to change not only the ampères, but also the number of volts very conveniently. This system has proved a complete success, and apparatus constructed accordingly allow a finer and more gradual regulation of the E.M.F. than can ever be obtained by the best current collector connected with batteries.

Shunt.—I will try to explain the principle of this shunt connection, which is the same in all apparatus, whether they are intended for galvanisation or cautery.

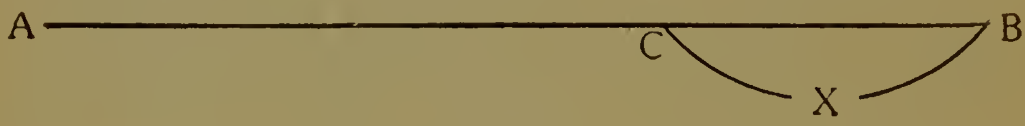


Fig. 21.

If a current passes through a resistance A B, and we connect another conductor with two points of this circuit, say at C and B, a current will circulate in this second conductor as well, and the E.M.F. in this shunt circuit C X B is in the same proportion to the E.M.F. between A and B as the resistance between C B is to that between A B. If, for instance, the E.M.F. between A and B is 100 volts, and the resistance in C B one half of that in A B, then the E.M.F. in C X B will be 50 volts, or it would be 10 volts if the resistance in C B were only one-tenth of that in A B. According to the spot were C is connected we can obtain for the shunt circuit C X B any E.M.F. we like, from 0 upwards; only, of course, it cannot exceed the E.M.F. existing between A and B, and if the apparatus is so constructed that C is movable, the E.M.F. in C X B can easily be varied by moving the point C.

With this arrangement we need not employ more volts than are necessary for obtaining the desired strength of current in X. X represents either a patient, or a cautery burner, or spark coil, or small lamp, etc.

The strength of current in the shunt circuit depends on the E.M.F. and the proportion of the resistance in C X B to that in C B. If these resistances were equal, the current would have an equal strength in both loops; if the resistance in C X B is greater than that in C B, more current will pass through C B than through C X B.

If the current in C X B is interrupted near X there will be no spark, because the current in A B has not been broken, only a part of it has been shunted to another branch: moreover, it has been proved that with such a connection a current from a dynamo can be endured just as easily as a similar current from a battery; the only disadvantage is, that the part of the current passing through C B is wasted. The currents employed for galvanisation, electrolysis, faradisation, and surgical lamps

are so weak that this waste is not worth mentioning, it will scarcely amount to one shilling during a whole year ; for cautery or exciting spark coils the loss is greater. However, the electricity generated by dynamos is much cheaper than that produced by batteries ; we shall refer to the actual cost later on under rheostats for cautery.

Apparatus for Galvanisation and Electrolysis.—In order to regulate currents of 100 to 250 volts conveniently for galvanisation and electrolysis, a specially constructed rheostat is used. Over 500 turns of a fine platinoid wire are wound round a slate core, and the single turns are insulated from one another. As the maximum current required for electrolysis does not exceed 0·3 ampère, the wire may be thin without any risk of its getting hot. In order to obtain the required current

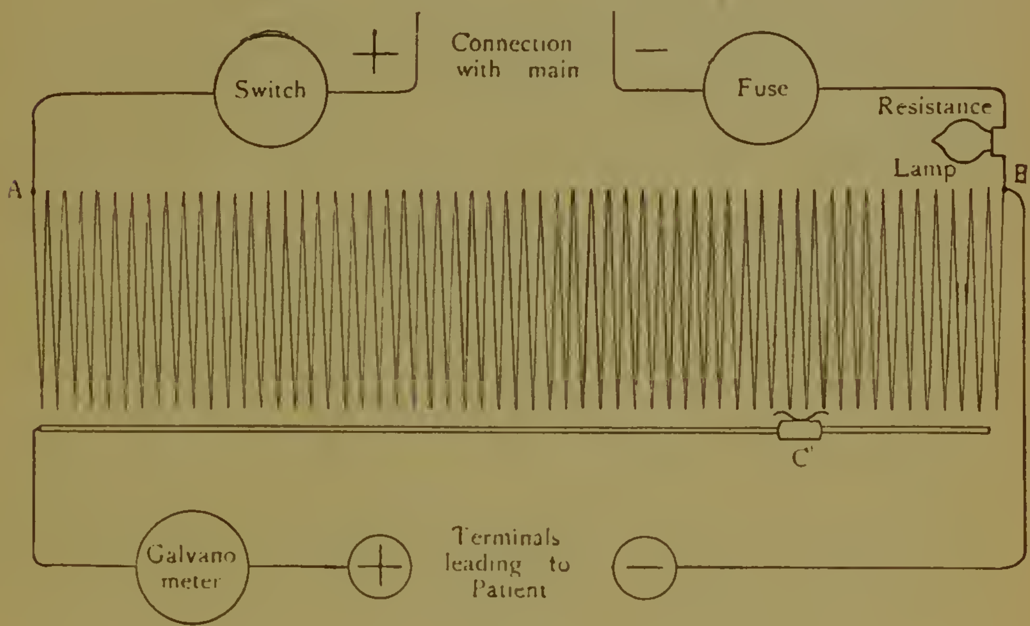


Fig. 22.

through the patient's body, the platinoid wire must have a resistance of not less than 400 ohms. The point C consists of a sliding spring movable along the rheostat, as shown in the diagram. An incandescent lamp of 8 to 16 candle power is also inserted in the circuit, partly to protect the patient against a dangerous dose, partly to increase the resistance to prevent overheating of the platinoid wire through too much current. It also shows the doctor when the apparatus is connected with the main, for the lamp remains burning as long as the switch is closed, whether the electrodes are connected with a patient or not.

If the sliding spring is on the right hand side, near B, the E.M.F. between the terminals leading to the patient is only a small fraction of a volt. It will increase as we move the spring towards the left. In consequence of the large number of turns the increase is very gradual, about 0·14 volt per turn, and when the spring is quite on the left hand side, near A, the maximum number of volts obtainable has been reached.

With a 100-volt supply and an 8-candle lamp in circuit, this maximum will be about 60 volts. This rheostat we call a volt regulator* ; it may also be used in connection with batteries.

The diagram shows a galvanometer, which should always be employed with these apparatus. If batteries are used, the number of cells is an unreliable control, but still some sort of a guide to estimate the current, but with a 100-volt current without a galvanometer one works absolutely in the dark.

There are yet other accessories which may be inserted in the shunt circuit, as current reversers, etc., but as they do not differ from those used for batteries, we refer the reader to pages 15—20.

Is the Current from Dynamos quite Safe? We have been asked, is it safe to use currents from dynamos for medical purposes? It is impossible to settle this question in general, it depends too much on special circumstances.

The fear has been expressed that, by some accident, the E.M.F. might suddenly rise to dangerous proportions. This objection is admissible only in towns where both low tension and high tension systems are used, and where the wires are *drawn overhead.* A collapse of the supports caused by fire or storm might bring the different wires in contact. But all the cables in Great Britain are laid underground, and this makes accidents of such a nature impossible. Moreover, a dynamo built to supply 100 volts cannot possibly yield suddenly 200 or more volts. In our opinion, these apprehensions are unfounded.

There is, however, another danger. The current might be suddenly broken, or the dynamo might be switched off and a battery of accumulators switched on instead. Such a change is likely to happen once in the morning and once in the evening in most electric light stations. If the strength of current applied to the patient does not exceed, say, 20 milliampères, such an unforeseen break may be disagreeable, but not dangerous; and if 20 milliampères are not exceeded, we consider the current from a dynamo quite as safe and more convenient than the current from a battery; but it is different when heavier currents are to be employed, for instance, for electrolysis. A sudden break while 50 milliampères are passing through the head, or 200 milliampères through the abdomen, might have serious consequences; and if a doctor intends to employ currents as strong as this, we should advise him first of all to obtain information from the engineer in charge of the electric light station, whether, and at what times of the day breaks will happen, and whether it is likely or possible that breaks will happen at any other time. We should not advise the use of this current for *heavy* applications for electrolysis, until re-assuring information has been obtained from the responsible engineer.

A possible danger may arise under the following circumstances: An imperfect insulation from earth of the conductors in the street will cause a leakage of current (in some systems one pole is "earthed" intentionally). If patient or operator happen to stand on damp ground, they too are connected with such a leaking pole, and when the second pole is connected with a cystoscope, cautery burner, or electrode, they may get a disagreeable shock, the strength of which depends on the amount of leakage, the E.M.F. in the main, and the insulation of the patient from earth. Safety lamps, fuse wires, etc., are no protection against these shocks. The only real protection is to insulate patient and operator efficiently from earth. A *dry wooden* floor is a fairly good insulator. Linoleum on wooden floor will suffice nearly always. If, however, the leakage is very bad, or the floor very damp, a perfect insulation can be obtained without serious expense by means of a board placed on porcelain or glass insulators. For an electrical bath the tub should be of porcelain and no metal pipes should be in contact with the water in the bath.

* Dr. Hedley, of the Electrical Department, London Hospital, writes to us about the Volt Regulator as follows: "*I have tried the volt regulator, and I think the sliding shunt is very smooth and satisfactory. The compactness and the arrangement are wonderful.*

Apparatus for Faradisation.—A coil for faradisation is frequently connected with the above described apparatus for galvanisation. A current of about 0·5 ampères is required to work these coils, and the easiest way of obtaining it is by inserting an incandescent lamp in the circuit as a resistance. With 100 volts, a 16-candle-power lamp is the most suitable, and a 32 to 50-candle-power lamp is required for 200 or 230-volt installations. Combined apparatus of this kind can be used for exactly the same purposes as the combined batteries. De Watteville's key (see page 19) can also be used with them.

We cannot find any advantage in trying to utilise the current from dynamos for *portable faradic coils*, except in the cases mentioned below. One or two Leclanché dry cells are sufficient for working them, and these cells are now so convenient and reliable, that, according to their size, they will last one or two years without requiring attention. Should the coil be fed from a dynamo, an incandescent lamp would be required instead of a dry cell, and a special lamp holder as well (*see No.* 950). The lamps are breakable, and do not last for ever; they are therefore neither cheaper nor more reliable than dry cells, and in order to be able to use the apparatus in the houses of patients, it would be necessary that the same current, and the same wall plugs, etc., would have to be available there, and this cannot always be had.

For these reasons we consider dry cells the most convenient for portable medical coils, intended for private practice: but for coils remaining in a consulting room, or for coils to be used in hospitals, it is an advantage to be able to connect them with a wall plug or a lamp holder, and for such cases the various coils are provided with an incandescent lamp, or the series lamp holder No. 950 may be used.

The Alternating Current from Dynamos can be used for Faradisation only to a very limited extent. The alternations are so extremely rapid (12,000 per minute) that the muscles have not got time to contract or relapse completely, they remain in a semi contracted state, and the effect is totally different from that produced by a medical coil, with its comparatively very slow vibrations. But in cases where it is intended to give a few shocks only, the alternating current may be used, if either a transformer or else a volt regulator (*see* page 48) is put between the patient and the main.

Surgical Lamps.—The connection described for galvanisation and electrolysis is also useful for reducing the current from dynamos for the small surgical lamps, which require between 4 and 12 volts, only the wire used for the rheostot must be somewhat thicker than that sufficient for the volt regulator, in order to stand, without getting hot, the maximum current (about 2 ampères) which these little lamps require. The resistance of the rheostat, however, need not exceed about 50 ohms. The carbon filament of the resistance lamp connected with the rheostat

should not be thinner than the carbon filament in the small lamp; with 100 volts a 50-candle lamp, and with a 200-volt supply one 100-candle lamp, or better, two 50-candle lamps connected parallel will generally be sufficient. Rheostats of this kind can be used equally well on continuous or alternating current circuits.

Apparatus for Cautery and for working Spark Coils for Roentgen Rays differ very much from those for galvanisation; they require at least 200 times as much current. Cautery burners require from 7 to 15 ampères and spark coils from 4 to 16 ampères, whereas for galvanisation and electrolysis less than 0·3 ampères are used as a maximum. Wires suitable for the rheostats for galvanisation would melt immediately if a current of 20 ampères were forced through them. A current of 20 ampères requires either carbon rods or thick wires—for instance, platinoid wires of not less than one-eighth of an inch diameter. Even with this diameter they will keep cool only if air has got free access to them. According to Ohm's law, 6 ohms suffice to reduce the current to 16 ampères on a 100-volt circuit, but with such a diameter about 100 yards, or 12 lbs., of platinoid wire are necessary to obtain a resistance of 6 ohms, and double the quantity will be required for a 200-volt supply.

Whether the currents are produced by dynamos or by batteries, the apparatus required for galvanisation and electrolysis are entirely different from those required for cautery or spark coils, and the same rheostat cannot be used for both purposes.

The diagram shows that the principle of the connection is exactly the same as that described on page 46. Parallel with the resistance wire a lamp is connected, which burns as long as the switch is closed. It serves only as a signal light, to remind the operator that a current passes through the apparatus, and that immediately after the operation the switch should be opened to prevent waste.

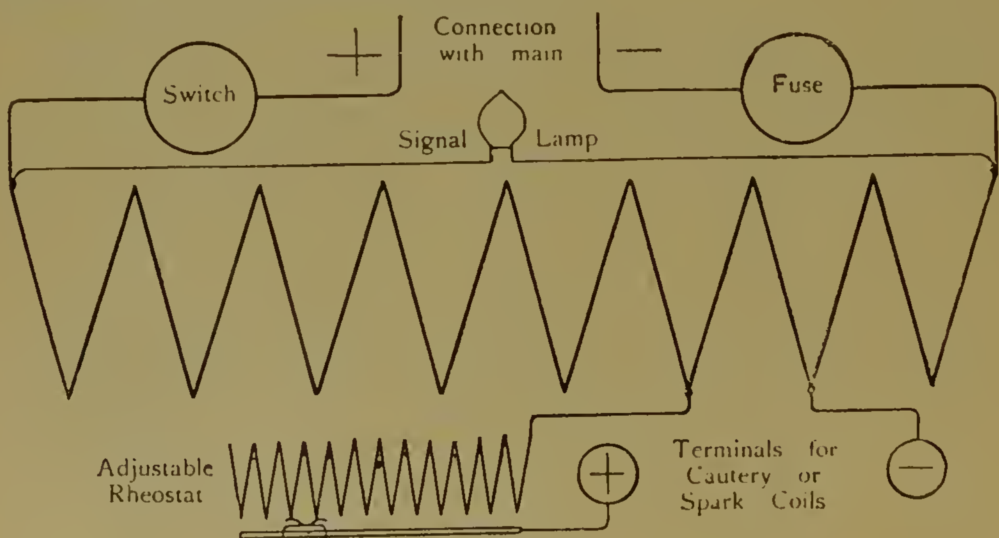


Fig. 23.

For rheostats for cautery it is sufficient to connect C permanently, so

that 10 to 12 volts (or any other desired voltage) are available in the shunt, and by inserting a small adjustable rheostat the current in the shunt can be controlled gradually and conveniently. In order to obtain a sufficient amount of current in C X B it is important to arrange the resistances so that that in B C is higher than that in C X B. X means here the cautery burner, or the primary wire of a spark coil.

As long as the switch is closed, a current of 100 volt and 16 ampères (1,600 watts) passes through the rheostat and has to be paid for, and only about 12 volts and 16 ampères (192 watts), that is only one-eighth, are utilized in the shunt circuit. This is a considerable waste, but a more economical arrangement has not yet been found and seems to us impossible. If, therefore, the apparatus is left connected with the main for one hour, 1·6 units are consumed with a 100-volt supply, and twice as much with a 200-volt supply.* The price of the unit being 6d., the cost for using the apparatus for one hour on a 100-volt supply will be 10d. This compares still favourably with the cost of the electricity produced by batteries. A bichromate battery requires about two shillings' worth of chemicals to keep a cautery burner incandescent for one hour, not to reckon the cost of the zinc consumed, and as a rheostat does not deteriorate, and requires no time for cleaning and recharging, it is certainly preferable, notwithstanding this waste.

All the cables and fuses in the house which lead to such a rheostat must be of a diameter which allows a current of 16 ampères to pass without heating them.

Motor Transformers.—A more economical way of utilizing a 200-volt current for cautery, is to drive a small dynamo by means of an electric motor (they can both be united in one machine), to obtain in this way a current of lower E.M.F. and a greater number of ampères. This is achieved in the following way: The armature of the dynamo is wound with a long fine wire, the length and diameter of which are chosen according to the E.M.F. of the supply and the number of watts required for the cautery, etc. The current from the main passes through this fine wire and causes the armature to run as a motor. A second, shorter and stouter wire, also wound round the armature, rotates consequently in the magnetic field, and a current is induced in it, which can be taken off a separate collector connected with this wire. The volts and ampères of this current depend on the length and thickness of the wire, and on the rapidity of the revolutions. A current of 100 volts and 2½ ampères (250 watts) can be transformed into about 10 volts and 14 ampères (140 watts). Cautery burners or spark coils may be connected directly with such transformers, and accumulators may be charged from them.

* A current of 1000 watts (for instance, 100 volts and 10 ampères, or 200 volts and 5 ampères) running for one hour is the Board of Trade unit, for which the Electric Light companies charge at present between 3d. and 6d

These motors require, however, some attention. They have to be kept oiled, the rapidity of the revolutions must be controlled with a special rheostat, and the brushes and collectors get used up in course of time. The original outlay for these transformers is about twice as much as for the rheostats, and for these reasons we consider them advisable only, where *larger* quantities of electricity are required; for instance, in a hospital with a 200-volt supply, and several departments for throat, ear, etc., in which cautery or spark coils are being used. In such a case it would certainly be cheaper to get accumulators charged for the various departments by one of these transformers, than to place a rheostat in each separate department.

For the small quantities of current used in private practice, even with a busy specialist, it seems, however, doubtful whether the motor transformer is really more economical in the long run, and a rheostat is certainly more convenient.

It would also be possible to convert the continuous current by means of a motor into an alternating current, and use a transformer; but if a motor is to be employed at all, the motor transformer certainly offers more advantages.

Accumulators.—By means of accumulators the continuous current can also be utilized for cautery and spark coils. As to the charging, correct connection of the poles, number and size of cells, etc., we refer to pages 28 to 31.

Incandescent lamps are inserted as a resistance for controlling the charging current. If these lamps serve only as a resistance, the waste of current is just as great as with the above described rheostats. If, however, the connections are made so that the resistance lamp illuminates a hall, bedroom, etc., there is no waste, and, moreover, under such conditions the accumulators get charged regularly every day for some time. This is the only means to keep them reliable and in good condition for a long time, and in this case the plates need only be renewed once in several years. It is not necessary to use extra strong cables or fuses, for the smallest size wire allowed by the Fire Insurance and Electric Light companies is fit to carry the current required for charging. No. 1675 in the catalogue shows switchboards fitted with all accessories for charging the accumulators and for conveniently controlling the discharging current for cautery, spark coils, etc.

The Alternating Current is suitable and very convenient for cautery and surgical lamps. As shown under Faradisation, on page 35, a current is generated by induction in an adjoining conductor. In medical coils, we transform a current of about 1·5 volts, and 0·5 ampères into a current of 20 to 200 volts and 0·01 ampères or less, and in the same way a current of 100 volts and say 2½ ampères can be transformed into one of about 10 volts and 20 ampères, and can then be used for cautery burners

and surgical lamps. The alternating current is intermittent, and does not require an interrupter such as is used in medical coils. The apparatus is therefore very simple, as it consists only of an iron core, a primary and secondary wire, and a rheostat for controlling the strength of current.

Transformers for Cautery and Surgical Lamps.—The sketch shows two separate secondary coils, one for cautery and the other for surgical lamps. With these transformers the primary coil consists of many turns of fine wire; the secondary, however, has only a few turns of thick wire; the diameter of the wire and the number of turns has to be chosen in proportion to the number of volts and ampères which we wish to obtain from the terminals of the secondary. As long as the cautery burner is not used, very little current passes through the primary in consequence of the counter E.M.F. generated by the iron core. A signal lamp, as described with the rheostats on page 50, is therefore less important for the transformers. The wires leading to the transformers need not be of special size; No. 16, the smallest wire allowed by the Fire Insurance Offices, is quite sufficient.

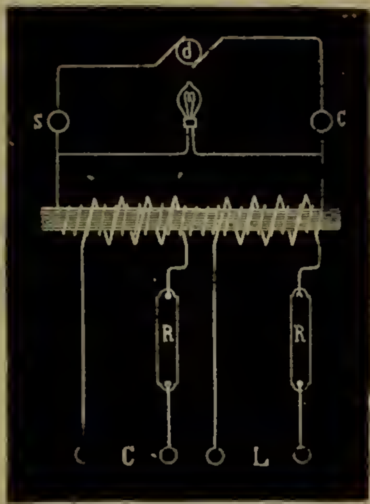


Fig. 24.

There are two ways of regulating the strength of current in the cautery burners. In Woakes' transformer one of the coils is made movable, as in sledge coils, and the E.M.F. in the secondary can be varied thereby. Or else the position of the two coils is fixed permanently, and the current for the different sizes of burners and lamps is regulated by means of a small rheostat inserted in the secondary circuit. With this latter arrangement, light and cautery can be utilised at the same time.

As far as convenience, reliability, and efficiency are concerned, these transformers cannot be surpassed, and as the current passing through the cautery burner is an induced current, there is no metallic connection between the patient and the mains in the street.

Sinusoidal Currents.—The alternating current can, moreover, be used for a new kind of treatment, very favourably mentioned in these last years by many authorities. The current obtained from an alternating

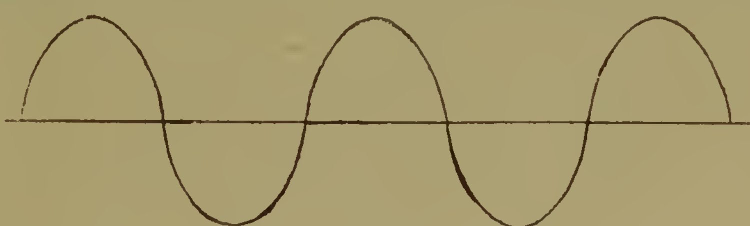


Fig. 25.

current dynamo is a sinusoidal current, and differs from the current obtained from a medical coil by not being so jerky and abrupt. The two diagrams show the curves of the current from an alternating current dynamo, and that from a medical coil.

The sensation produced by these two kinds of current is quite different, and patients can stand a good deal more current from an alternating current dynamo than from a medical coil.

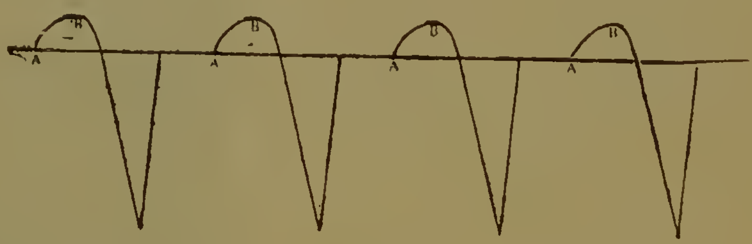


Fig. 26.

The most efficient and convenient way of controlling the 100-volt sinusoidal current from a dynamo and of varying its E.M.F., is by using a volt regulator as described on page 47.

A continuous current from a dynamo or a battery can be converted into a sinusoidal current by means of a small dynamo. From the second collector with which these machines are provided, a sinusoidal alternating current is obtained, and the strength of it can be most conveniently regulated by means of a graphite rheostat or volt regulator.

As mentioned before, the alternating current cannot be utilised for galvanisation and electrolysis. It has been suggested to convert it for these purposes into a continuous current, by coupling an alternating current motor with a small dynamo which yields a continuous current. This has been done with success for some technical purposes, where large quantities of electricity were required ; but the machines, whether big or small, require attention ; they have to be oiled, the speed must be regulated, the collectors are used up in course of time, and the intsallation costs about four times as much as a good Leclanché battery yielding the same number of volts, etc. The currents required for galvanisation and electrolysis are so small that a good battery requires re-charging only once in two or three years, and therefore a battery is in every way preferable to a motor transformer for these purposes.

The alternating current cannot be used for charging accumulators. If, however, in a large hospital many accumulators have to be charged, the coupling of an alternating current motor with a continuous current dynamo, as described above, can be made practical and efficient.

ROENTGEN X-RAYS.

In December, 1895, the scientific world was startled by the news of a discovery made by Professor Roentgen, of Wuerzburg. While experimenting with Crookes' tubes and fluorescent salts, he found that rays emanate from these tubes, which though invisible to the eye under usual circumstances, act like ordinary light on photographic plates, and moreover, that these rays penetrate substances through which ordinary light cannot pass, for instance, wood, ebonite, cardboard, flesh, etc., while other substances, like bones, several kinds of glass, etc., are less transparent to the effect of this light, and the heavy metals—iron, lead, platinum, etc.—are perfectly opaque. (The transparency seems to be in direct proportion to the specific gravity.)

Seldom before has an invention made such a stir. A great number of scientific men all over the civilized world began to experiment with the X-rays (as Professor Roentgen called them), and it was soon evident that the discovery would be of the greatest advantage for surgical diagnosis. Malformations and diseases of the bones, foreign bodies, fragments of bones, etc., could be easily detected by their help; and it can be ascertained whether broken limbs are correctly set. The movements of the heart, the position of the liver, larynx, etc., can be seen clearly on the fluorescent screen, calcification of the arteries, and some kinds of stones, etc., can be found. The rays produce also some physiological changes in the hair, nails, and skin, and they may have some effect on microbes.

The apparatus required to produce X-rays, and to make them visible, consist of—

(1,) **An Electrical Apparatus producing currents of very high E.M.F.,** some 50,000 to 500,000 volts are required. These are discharged into—

(2,) **Crookes' Tubes,** which consist of glass tubes with a highly exhausted vacuum wherein two electrodes are placed. The cathode, connected with the negative pole, is made now of a concave disc of aluminium. In the focus of this disc, at an angle of about 45 degrees, is placed a sheet of platinum, as anticathode* to intersect the cathode rays. Frequently this anticathode is connected with the positive pole, and serves at the same time as an anode, but some tubes have a separate anode. When the electrical apparatus is started, the gas molecules left in the tube are violently repelled from the cathode, which, by striking on

* The first hard substance on which the cathode rays strike is called anticathode.

the anticathode, are converted into X-rays (rays of another wave length). In order to make them visible we require—

(3.) **Photographic Plates,** or certain **Salts, which give a fluorescent light** under the influence of the X-rays. If, for instance, a hand is placed between the tube and a cardboard screen coated with such a salt, the flesh seems to have disappeared, and only the bones appear as dark shadows. In order to show the picture, photographic plates have to be exposed to the rays for a short time and developed in the usual way. Our illustrations show a hand and chest taken in this way.

There are different ways of producing currents of a high E.M.F.

Spark Coils are frequently used for this purpose, as they are most convenient and reliable. In principle they do not differ from the medical coils described on pages 35 to 40, in practice, however, there are some important differences.

The secondary wire has to be very long. To obtain sparks 10 ins. long a secondary wire about 10 miles long and about 0·2 millimètre (No. 36 B.W.G.) thick is required. Moreover, an exceedingly careful insulation is indispensable, as these sparks easily penetrate cardboard, wood, &c. More especially the primary coil has to be separated from the secondary by a stout ebonite tube, to prevent the spark discharging through the wire of the primary coil or through the iron core.

On account of the high E.M.F. it is impossible to wind the secondary wire along the primary in the same way as it is done in medical coils. The silk covered wire is first of all drawn through melted paraffin-wax, and thus when wound in sections on a separate machine has the appearance of flat discs. In mounting them on the coil, several sheets of paper, which have also been saturated in paraffin, are placed between every two discs of wire. The ends of the discs are joined together, and an ebonite sheet is placed between groups of about 6 discs. A 10-in. coil, for instance, is made up of 50 to 100 of these separate sections.

Condenser.—Spark coils must, moreover, be fitted with a condenser, which consists of many sheets of tinfoil, insulated from one another by sheets of paraffined paper. The first, third, fifth, &c., sheet of tinfoil are connected together, but are insulated from the second, fourth and sixth sheet; these latter are also connected. Each end of the condenser is connected with one side of the interrupter; the moment the primary current is broken, an extra current flowing in the same direction as the primary current is generated, and discharges into the condenser. The condenser gives off its charge partly through the accumulator, and partly when the current is made again through the primary coil. If there were no condenser, the extra current would be wasted in an enormous spark between the contacts of the interrupter. This spark would destroy the contacts quickly, and would, moreover, retard the suddenness of the break. As the E.M.F. of the induced current depends amongst other things on the suddenness of the break, the extra current would materially reduce the secondary spark. The importance of the condenser is best shown by the fact that a coil giving 10-in sparks with a condenser of suitable size, will yield only a 4½-in. spark with the same battery without a condenser.

The Interrupters on the spark coils are also very important for their efficiency. The length of the spark depends partly on the suddenness of the break, and partly on the strength of the primary current, both of which are much influenced by the construction and correct adjustment of the interrupter. The iron requires some little time to get saturated with magnetism, and the primary current requires some little time to reach its maximum, for, as explained on page 36, on closing the primary current, an E.M.F. opposed to, and retarding the primary current is generated by self induction and by the presence of the iron core. In consequence of this, no spark is discharged from the secondary in *making* the primary current. Sparks are generated in *breaking* the primary, and therefore they take the same direction. For these reasons it is very important, in order to obtain an intense discharge, that the contact is not interfered with until the magnetism and the primary current have had time to reach the maximum strength.

Up to the year 1898 the only interrupters known were the platinum interrupter and the mercury interrupter, both of which are still the most frequently used. In both the current is broken by the vibrations of a hammer (this has been explained on page 36, "Wagner's Hammer").

With the **Platinum Interrupter** the spring which causes the hammer to fly back must be of suitable strength. With many interrupters there is an arrangement for regulating the tension of the spring. The rapidity of the interruptions and the intensity of the sparks depend partly on the tension of the spring, and are increased if the screw bearing the platinum contact is screwed home. If, however, a certain limit has been exceeded, the hammer stops suddenly. They are used on account of their simplicity with all the smaller spark coils up to about 6 inch spark length. With larger coils it is a matter of taste whether platinum or mercury interrupters are preferred, but for large coils, giving sparks of 20 inches or more, mercury interrupters only can be used, as in these large coils the spark on the interrupter is so powerful that it would destroy platinum contacts too quickly. The platinum contacts have to be filed occasionally, and after prolonged use they must be replaced by new ones. On account of the rapid and regular vibrations, the platinum interrupters are preferred to the mercury interrupters for observations on the fluorescent screen.

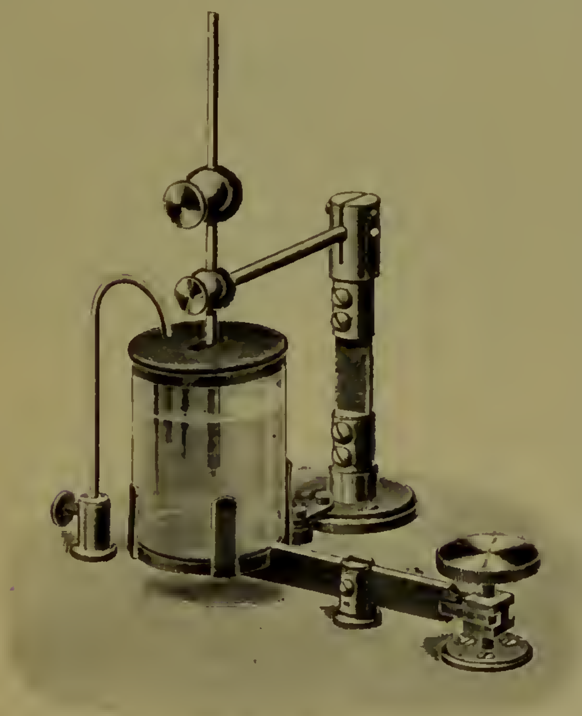


Fig. 28.

With **Mercury Interrupters**, the cup containing the mercury can be raised or lowered; moreover, the hammer is provided with a heavy ball, the raising or lowering of which regulates the rapidity of the vibrations, and the time during which the current remains closed. The paraffin oil, alcohol, or water covering the mercury extinguishes the spark on the interrupter more rapidly than the air does it on the platinum interrupter. In consequence of this, the sparks obtained from coils fitted with mercury interrupters are more intense and 10 to 20 per cent. longer than the sparks obtained with platinum interrupters under otherwise similar conditions. Mercury interrupters are preferable to the platinum interrupters for exposing photographic plates. The mercury has to be rinsed under a water tap after a few hours' working.

Motor Interrupters.—In order to regulate the time during which the current is closed, independently of the magnetism of the iron core, and to increase the number of sparks, interrupters are made in which a motor dips the contact pin in and out of the mercury. It is not quite easy to calculate the number of full-length sparks which may be obtained under the most favourable circumstances from platinum or mercury interrupters, but they are not likely to exceed about 800 per minute. With a motor interrupter, however, the number of sparks can be brought to some 1,200 per minute. If the speed of the motor is further increased, the length of the sparks diminishes rapidly, and with 2,000 revolutions of the motor per minute, they become too small and irregular to be of any use.

In 1898 two new interrupters were invented in Germany. Although they differ considerably in other respects, the one feature which they have in common is the great rapidity of the break. *This makes it possible to utilise a higher E.M.F. in the primary circuit* than has been possible with the slowly moving old interrupters, which would be burned up in a short time by a high E.M.F. The higher E.M.F. in its turn causes the primary current and the magnetism of the

iron core to reach the maximum in a shorter time, which makes it possible to reduce the time during which the current is closed. Under these conditions an extraordinary number of sparks (from 5,000 to 50,000 per minute) may be obtained; the eye gets the impression as if dozens of sparks were being discharged simultaneously, and sometimes the sparks form one thick arc of flame. The light of the fluorescent screen appears as steady as the light of an incandescent lamp, and the time necessary for exposing a photographic plate can be considerably reduced. The efficiency of the spark coils is raised to such an extent by these new interrupters that they are sure to supersede the old ones in course of time.

Fig. 27.

Wehnelt's Electrolytical Interrupter.—Dr. Wehnelt has invented an interrupter which is based on an entirely new principle. A glass vessel filled with diluted sulphuric acid (1 oz. of acid to 10 oz. of water) contains two electrodes of very different sizes; for instance, a large lead electrode and a short piece of platinum wire. If these electrodes are connected with an electric supply, electrolysis causes gases to form on the platinum which cover it and thereby interrupt the current. The heat explodes the gases, the acid regains access to the platinum, thus closing the current again. The photograph (Fig. 27) of the discharge of a coil connected with a Wehnelt interrupter shows the extraordinary rapidity with which this occurs.

A condenser is not required for a spark coil with an interrupter of this kind. The interruptions do not begin with an E.M.F. lower than 16 volts; with some coils even 24 volts are required as minimum. The best results are obtained with 24 to 50 or 60 volts; the number of interruptions increases with the E.M.F. used, but with 80 or more volts the anticathodes become so hot that few tubes can bear the strain for a reasonable time. In order to make it possible, nevertheless, to use the interrupter directly with a 100 volt supply, special tubes with a water-cooling arrangement of the anticathode were constructed, but, quite apart from their high price, they do not seem to be satisfactory either if 80 or more volts are used. It has also been recommended to insert resistances "in series" with the 100 volt current, but this is certainly of no use at all. On account of this difficulty many doctors are under the impression that the electrolytical interrupter is useless. But the fact that the tubes will not last with the high E.M.F. which happens to be supplied by the Electric Light companies is certainly not a proof that the interrupter is useless altogether, and most excellent results are obtained if a lower voltage is used. The current from the main may be utilized nevertheless, but instead of inserting interrupter and coil "in series" they must be inserted in a shunt circuit, so arranged that the number of volts can be varied between 20 and 60 or 70 volts. With this connection the ordinary tubes will last quite as long with the Wehnelt as they would do with other interrupters, and, as to efficiency and simplicity, the Wehnelt interrupter supersedes

A Normal Hand, 38 years old. The Negative was taken by us in June, 1896, on an Edwards Isochromatic *Medium* Plate, with a 6-inch spark from a Rhumkorff Coil. Distance of tube from plate 8 inches.

Taken with a 6-inch spark in 1896.

every other interrupter, old or new. If connected with a battery of 12 to 24 accumulator cells, the same good results are obtained.

If the Wehnelt interrupter is in constant use for half an hour, the acid grows hot; and with a certain temperature, reached after about 45 minutes' continuous use, it stops working. Should it be necessary to use it so long without interruption, the heat can be kept down by using as large electrode a lead tube through which cold water is circulating.

The second new interrupter, the so-called **Turbine Interrupter**, was invented a couple of months before the electrolytical interrupter. A jet of mercury, which is ejected by centrifugal power, strikes alternately on contacts or on the insulating wall of the vessel in which the interrupter is placed, and with 50 volt in the primary, a discharge similar to that of the electrolytical interrupter is obtained. This is an excellent interrupter, and the most ingenious one, but it is not so much used in this country on account of the greater simplicity and cheapness of the electrolytical interrupter, and for this reason we abstain from giving here a more detailed description.

In the summer of 1900 **Mr. Mackenzie Davidson** constructed a very simple **Motor Interrupter.** A motor is placed in a slanting position on the edge of a vessel filled one-third with mercury and two-thirds with paraffin oil. A slate disc bearing two contacts is fixed on the prolongated axle of the motor, and the lower part of it is immersed in mercury. The current is made and broken by the revolutions of the motor. The rapidity of the revolutions can be regulated by a small rheostat and must be adapted to the E.M.F. used in the primary circuit. While the motor is running slowly, the interrupter can be used with a low E.M.F. (*i.e.*, with 12 to 20 volts, according to the size of the coil used), but in this case there will be only a comparatively small number of sparks from the secondary. The higher the speed of the motor is raised, the higher an E.M.F. can be used in the primary without danger of overheating the primary coil, and with about 50 volts an unbroken arc of flame, such as Fig. 27 shows, is obtained with this interrupter, too.

Size of the Coils.—When Professor Roentgen made his discovery, it was generally believed that the minimum spark length required for producing the X-rays would be 10 ins. By means of improved tubes however, very good photographs of hands, arms, legs, etc., were obtained soon afterwards with 4-in. and even 2-in. sparks ; 6-in. sparks gave very good pictures of chest, heart, head, etc. For this reason, 6-in. coils were most frequently in request for some time. Since then the opinion has again decidedly been in favour of larger coils. The effect of the rays can of course be accumulated on a photographic plate, and by longer exposure a 6-in spark may produce results similar to those obtained by a 12-in. spark with shorter exposure ; but it is obvious that with all living subjects the shorter exposure has a decided advantage. It is, however, more especially the brightness of the fluorescent light, which increases with the length of the spark, so that in using large coils, a good deal more can be discerned on the screen than if a smaller coil were employed. In consequence of this, 10-in. spark coils are at present those most frequently asked for, and coils with 15-in., 20-in., and even longer sparks are often employed.

There is another reason in favour of larger coils. The vacuum in Crookes' tubes becomes gradually higher for reasons as yet unexplained, and the resistance of the tubes increases thereby, so that longer sparks are required to overcome it. If a tube, which worked well first with a 6-in. spark grows higher, the owner of a 6-in. coil has to lay it aside as

useless, whereas, if a 10-in. spark is available the tube can be used for a considerable time longer.

The length of sparks of large coils can easily be reduced by a rheostat inserted in the primary circuit, so that even a tube requiring only a 3-in. spark can be worked with a 20-in. coil. Coils should never be started without a tube or a discharger being connected.

Rheostats and Batteries to work Spark Coils.—According to the length of the spark the coils require currents of 8 to 20 volts (8 to 10 volts for 6-in. coils, about 12 volts for 10-in. coils, and 16 to 20 volts for 20-in. coils), and 5 to 15 ampères. Where a *continuous* current from a dynamo can be obtained, this is the most convenient source of electricity. The rheostats for cautery described on page 50 give the required number of volts and ampères, and if desired they can be so far altered that the number of volts is variable as well as the number of ampères. If the continuous current is not laid on, but facilities exist for getting accumulators recharged, these would be the most suitable batteries (see pages 28-31 concerning accumulators). The number of cells required depends on the number of volts mentioned above. The capacity of the cells should not be less than about 30 ampère hours for coils of 6 ins., and 50 to 100 ampère hours for coils of 10-in. to 20-in. sparks. A rheostat is necessary for regulating the strength of current.

Bunsen or Grove cells might be used, but they are very inconvenient, as they have to be charged, emptied and cleaned every time. Leclanché cells, dry or liquid, cannot be used for such heavy currents.

Where there are no facilities for getting accumulators recharged, *large* bichromate cells may be used. The cells should have two carbon plates each, of at least 6 ins. by 9 ins., they should hold not less than 2½ pints of acid, and the distance between carbons and zincs should not be too small. Under such conditions, a perfectly constant current of even 15 ampères can easily be kept up for hours. The larger the cells the more constant they are (see page 25 about bichromate cells).

For field hospitals, the most suitable sources of electricity are small dynamos, with fly wheels. Two men are required to drive them.

There are other apparatus besides spark coils by which currents of high E.M.F. may be generated.

Wimshurst Machines may be used, and have been highly recommended by some doctors. As far as the light on the fluorescent screen is concerned, it is as steady as that of an electric lamp. The intensity of the rays depends on the size of the machines, on the rapidity of the revolutions, and on the quality of the tubes. Machines with four plates of 30 ins. diameter seem to be about the smallest size useful for this purpose, but machines with twelve plates of 36 ins. diameter give excellent results. In order to be protected from dust, damp, etc., these machines should be

kept under a glass case. They have to be driven by a motor, and the most convenient is an electrical motor, which may be worked from the main or from accumulators, or small gas or oil engines can be used.

It need hardly be mentioned, that machines with glass plates of such a diameter, revolving at a high speed, are liable to break. They take up much room, are not portable, and are rather expensive. They require more careful attention and treatment than spark coils, and in hot weather they are not quite as reliable.

The steadiness of the light obtained on the fluorescent screen is not superior to that produced either with the turbine interrupter or with the electrolytical interrupter.

Tesla Transformers gave rise to great expectations some time ago. They yield an extraordinary supply of sparks, of any desired length, and moreover, they can be fed conveniently from continuous or alternating current supplies, available in most towns. The 100 to 250 volt currents are first raised to about 6,000 volts by means of an ordinary transformer, the secondary terminals of which are no doubt rather dangerous to life. This current is connected with a spark gap, a condenser, and the primary of the Tesla coil, which consists of a few spirals of a stout copper wire. One layer of many turns of a fine wire forming the secondary of the Tesla, is wound round this primary. Transformer, condenser, and Tesla coil are immersed in a tank filled with oil. The discharges of the Tesla are not dangerous. Good results have been obtained, but few tubes will stand this enormous strain for any length of time, and the deafening noise they make is not pleasant. On account of these difficulties many of the owners of Tesla transformers have returned to spark coils.

Crookes' Tubes.—After the coil, good tubes are the most important item of the Roentgen apparatus. Professor Roentgen, when he made his discovery, used a tube in which the electrical discharge took place between a *flat* aluminium cathode and an electrode placed at a right angle to it, and out of the way of the cathode rays, so that they struck on the glass opposite to the aluminium electrode, and thereby got converted into X-rays. Soon afterwards, Mr. Jackson, of King's College, London, found out that more intense X-rays can be obtained if the cathode is made concave, and if a platinum sheet is placed in the way of the cathode rays under an angle of 45 degrees, so that the conversion takes place on platinum instead of on glass. Tubes of this kind had been used by Sir William Crookes to show the generation of heat by the cathode rays, and they are now universally in use.

A great many efforts have been made since to further improve the tubes. The correct degree of exhaustion, the size and shape of the glass bulbs, different kinds of glass, the shape, number, size and distance of the electrodes have been investigated, and the results showed that the *best pictures are obtained if the anticathode is placed in the exact focus of the cathode rays** ; that the cathode and anticathode

* In the earlier tubes the temperature of the platinum rose quickly to red or white heat, and it happened repeatedly that the platinum was pierced by the cathode rays after a short time. To prevent it, the anticathode had to be placed a trifle inside or

must be well polished, and the latter must be perfectly plain. Chemicals have been introduced into the tubes for regulating the vacuum.

No great improvement has been made since then, but these experiments have helped to show under which conditions the best results are obtained, and certainly the average quality of the tubes is now infinitely superior to those of 1896; and at the same time first-class tubes are much cheaper. In 1896 fancy prices were willingly paid for a tube showing the heart and ribs on the fluorescent screen with an 8-in. spark, whereas now almost every tube sold gives these results, and the time of exposure is now less than one-half of what it used to be at the end of 1896.

Distance of Tube from Object and Screen or Plate.—The tubes are suspended in a stand, and connected with the coil by means of spirals of thin copper wire covered with gutta percha or india-rubber. When the electric current is turned on the space between anode and cathode has the appearance of being filled with bright apple green light (the colour of the light depends on the kind of glass used), and the other half of the tube remains colourless. In this case the direction of the current is correct; or else the walls of the tube only will show an irregular patchy fluorescence, and then the direction of the current is wrong, and the current reverser provided on every spark coil has to be turned immediately.

The anticathode should be placed opposite the object to be examined, and the distance between tube and object depends on the size of the photographic plate and the thickness of the object. With small objects the distance need not exceed 6 in., but if a chest or something similar is to be photographed, the tube should be about 30 ins. away, to obtain an even illumination of all parts of the plate, and to avoid distorted shadows.

Life and Treatment of the Tubes.—In some tubes an absorption of the few remnants of gas left in them takes place. The resistance they offer to the current is increased thereby, and longer sparks are required to overcome it, the tubes grow higher in vacuum. Some tubes change only very slowly and can be used for hundreds of exposures, whereas others may get higher after a short time, and it is impossible to say beforehand how long a tube will last. It is therefore advisable for an owner of a coil to select tubes which will work well with a coil smaller than his own, in order to have a margin left if the tubes become higher. It is our conviction that these changes are slower in tubes containing two anodes, than in tubes which have only one anode, but it is almost impossible to prove this except by experience. High tubes can be kept in use for some time if they are warmed with a spirit or Bunsen flame before starting the apparatus. The flame should be moved to and fro, because the thin glass is apt to get soft quickly, and then the enormous pressure of the atmosphere would destroy the tube at once. If the tube is too high for the available sparks they will discharge outside the glass walls, and the consequence is the speedy destruction of the tube, because a spark will pierce the glass. The holes thus made are too small to be seen, but large enough to admit some air into the tube.

Penetrating Power of the Tubes.—On the fluorescent screen different tubes produce very different results. Some cause the bones to appear grey, and slightly less transparent than the flesh. With others, the contrasts are more marked, the bones remain black, and only the flesh is transparent. The latter are more suitable for taking photographs, but the first mentioned have a higher penetrating power, and are more useful for the screen, for making the heart, &c., visible. Negatives made with them have a foggy appearance, without contrasts. Shorter exposure will not alter this, as it is caused through the fact above mentioned, that the rays generated in such tubes make the bones also transparent, and because in this kind of tubes X rays do not emanate from the platinum reflector only, but

outside the focus of the cathode rays; in this way the shadows produced are less sharp, and the image is astigmatic. Dr. Mackenzie-Davidson suggested therefore the use of osmium for the anticathode, instead of the platinum, because osmium can withstand the force of the cathode rays, even if it is exactly in the focus of the concave aluminium cathode. But the great difficulty of procuring osmium in solid form—quite apart from its price—must prevent such tubes from coming into general use. Moreover, the platinum reflector in most tubes is supported now by a stouter disc of aluminium to prevent the heating, and thus protected it can be placed in the exact focus of the cathode rays without risk of speedy destruction.

also from the glass walls of the tube. They tend to make the outlines less distinct, and reduce the contrasts still further.

As the tubes grow higher, the penetrating power of the X-rays increases, but tubes of high penetrating power can be so much reduced by heating them in the above described way, that the shadows of the bones appear black again. In selecting tubes, it ought therefore to be considered, whether they are intended for screen work or for taking photographs, and whether they are to be employed for thin objects, like hands, arms, etc., or for the thicker parts of the body, such as the chest, etc.

Fluorescent Screens.—The property of the X-rays to render certain substances fluorescent enables the eye to see not only the shadows of the bones, but to watch even the movements of the heart. Barium platinum cyanide has proved to be the most sensitive material, as it gives the brightest light under the influence of the X rays. It is therefore exclusively used now for fluorescent screens intended for direct observation. It gives a greenish yellow light. Paper or parchment is stretched on a frame, is coated with glue, and covered with the Barium platinum cyanide salt. To obtain an even light, free from bright and dark clouds, the salt must be laid with even thickness throughout, and this can only be accomplished by machines. In using the fluorescent screen, it is important that the interrupters should vibrate rapidly and make contact regularly. Clean mercury or platinum contacts are therefore important to avoid flickering.

Fluorescent screens can only be used in dark rooms. In some cases it is even necessary to cover the tube itself with a cloth, or to place a large black screen between tube and operator, and also to put a cardboard box over the platinum interrupter, in order to hide the light of the tube as well as the sparks of the interrupter. There are appliances (see illustration No. 1556 in price list) which makes it possible to use the screen in daylight; they are convenient in many cases, but the results can never be compared to those obtained in a dark room.

Fluorescent screens may be used, not only for direct observation, but also for reducing the time of exposure of photographic plates.

Accelerating Screens.—In order to reduce the exposure, a fluorescent screen is laid *closely* on the coated side of a photographic plate. If a space were left between, the picture would become hazy. The X-rays have thus to penetrate the object first, the fluorescent screen afterwards, and the sensitive film of the plate last. In this manner the X-rays, which do not get perceptibly weakened by penetrating the screen, as well as the light emitted by the fluorescent screen, act simultaneously, on the plate. The illustration shows their importance and efficiency. One half of a photographic plate was covered with a screen; the uncovered half is not fully exposed, whereas that half covered by the screen shows more detail. Accelerating screens are not wanted for thin objects, as in such cases the exposure required need never be long, but if a chest or hip has to be photographed, they are of advantage. The exposure is reduced most (about to one-fourth) by using the same

screens which are employed for direct observation. Formerly these platinum screens produced an objectionable coarse grain on the negatives, due to the comparatively large crystals of the platinum salt. With the newer screens this grain is now scarcely visible.

Tungstate of Calcium Screens may be used also for shortening the time of exposure. They give no appearance of grain, and are much cheaper than the platinum screens, but the light emitted from them is considerably weaker, and this makes them practically useless for direct observation and less effective for accelerating exposure.

In using platinum screens for reducing exposure, *isochromatic* plates, should be used, but in using tungstate screens, *ordinary* plates should be used.

Photographs.—Compared with the examination by a fluorescent screen the photographic process has the disadvantage, that the results are visible only after the plates have been developed and fixed; this makes it a little more complicated. On the other hand it has the great advantage of showing more detail and furnishing a permanent record.

Photographic plates, films, or papers are wrapped in black paper in the dark room, or, more conveniently, they are put into a light tight envelope of black or red paper, or silk. Thus protected the plates may be exposed to the X-rays in a room illuminated by daylight. The object to be photographed should be *as close as possible to the plate* and should keep as quiet as possible during the exposure. In using glass plates it is important that the coated side should face the tube, partly to obtain sharp outlines and partly because some kinds of glass are rather opaque to the X-rays. The store of unexposed or undeveloped plates must not be near the tube, otherwise the rays would act on these as well.

Duration of Exposure.—General rules cannot be given as to the correct time of exposure. It depends firstly on the quality of the tubes and the spark length, secondly on the thickness of the object and the distance between tube and plate, thirdly on the plates and the way of developing them. According to these conditions the time of exposure will vary from a few seconds for hands, arms, and legs, up to ten or fifteen minutes for abdomen, etc. How the exposure can be shortened by means of a fluorescent screen has been described on page 63 under accelerating screens.

There are different opinions as to the most suitable kind of plates, whether medium or rapid speed, whether ordinary or isochromatic plates are more suitable, but there is no doubt that a thick layer of an emulsion rich in silver is more important than mere rapidity of the emulsion. The most sensitive plates are, as a rule, thinly coated and contain less silver than plates of medium speed, and the latter are also capable of giving greater density and contrasts. Isochromatic plates give, with three to four seconds exposure, the same results as ordinary plates with about five seconds exposure.

Development.—We do not intend to give general instructions for developing; we must refer the reader to the numerous works about photography, but a few hints may be welcome to the one or other.

The formulas for development contained in the directions for use given in photographic books, and those supplied with the plates by the makers, are all intended for portraits or landscapes, where the contrasts between light and shadow are much stronger, where a "soft" picture is aimed at, and for which "half-tones" are indispensable. In Roentgen photographs there is less contrast, and in the majority of cases, for instance, in hunting for a foreign body, a fracture, or a dislocation, etc., a "hard" negative, that is, a negative with great contrasts between flesh and bones, is desirable, and the half-tones are not wanted. Consequently, the developers which are apt to give clear shadows and black high lights are well suited for our purpose. Of the older developers hydroquinone has got the greatest tendency to produce hard negatives, and is for this reason avoided by professional portrait photographers. For Roentgen photography it is most suitable for this very reason. The only disadvantage of it is the great sensitiveness towards changes in temperature. Metol is very good too. Moreover, the quantity of alkali should be reduced, and the quantity of bromide of potassium slightly increased; the development is retarded thereby, but better negatives compensate for the loss of time.

If it is not important to obtain the result at once, the following method of development is to be recommended: Place the plate in a clean dish, preferably in an upright position (there are porcelain troughs with grooves made specially for the purpose), cover it with a very diluted developer (about twenty to thirty times as much water as usual; boiled water has to be used to avoid air bubbles), cover the porcelain dish with some lid to exclude light, and leave the plate in this weak developer for a few hours. All detail which can possibly be brought out will be visible then, and should the negative be still thin, a developer of normal strength will produce the desired density in a few minutes. In this way more details can be obtained than with the usual way of development; the negatives will be free from fogs or veils, and it is the only method of obtaining satisfactory negatives from rather under-exposed plates.

Medical men who have not the time to develop their own negatives will easily find a professional or amateur photographer ready to help or to do this interesting work for them.

Before concluding, we have yet to refer the reader to a few of the many books in which he can study electricity thoroughly, and find good directions about the ways and means of applying it for various diseases.

BOOKS ON ELECTRICITY.

AYRTON, W. E., F.R.S. Practical Electricity. 1887.

JENKIN, F., F.R.S., Electricity and Magnetism. 1881.

THOMPSON, S. P., F.R.A.S. Elementary Lessons in Electricity and Magnetism. 1884.

BOOKS ON ELECTRO-THERAPEUTICS.

The books marked (*) can be supplied by us.

*ALTHAUS, JULIUS, M.D., M.R.C.P., M.R.I. The Value of Electrical Treatment. 3rd edition. 1899. Price 3/6.

*BEARD AND ROCKWELL. A Practical Treatise on the Medical and Surgical Uses of Electricity. 1891.

BIEDERMANN, W., M.D. Electro-Physiology. 1898. Price 20/-.

*DOWSE, T. S., M.D. Massage and Electricity in the Treatment of Disease. 2nd edition. 1899. Price 7/6.

*ERB, W., M.D. Handbook of Electro-Therapeutics, translated by A. de Watteville, M.D. Price 18/-.

*FENWICK, E. H., F.R.C.S. The Electric Illumination of the Bladder and Urethra. 2nd edition. 1889. Price 6/6.

*HEDLEY, W. S., M.D. The Hydro-Electric Methods in Medicine. 2nd edition. 1896. Price 4/6.

HEDLEY, W. S., M.D. Therapeutic Electricity. 1900. Price 8/6.

KEITH, Th., M.D. On the Treatment of Uterine Tumours by Electricity. *Brit. Med. Jour.*, June 8th, 1889.

*JONES, LEWIS, M.D. Medical Electricity. A Practical Handbook for Students and Practitioners. 3rd edition. 1900. Price 10/6.

*TURNER, D., M.D. A Manual of Practical Medical Electricity. 2nd edition. 1898. Price 7/6.

DE WATTEVILLE, A., M.D. A Practical Introduction to Medical Electricity. 2nd edition. 1884. (Out of Print.)

*REMAK, E. Elektrotherapie. 1886.

*VON ZIEMSSEN. Die Elektrizität in der Medizin. 1887.

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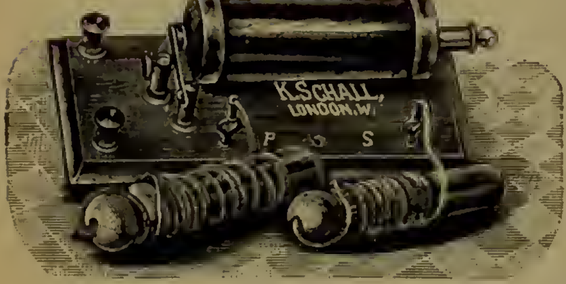

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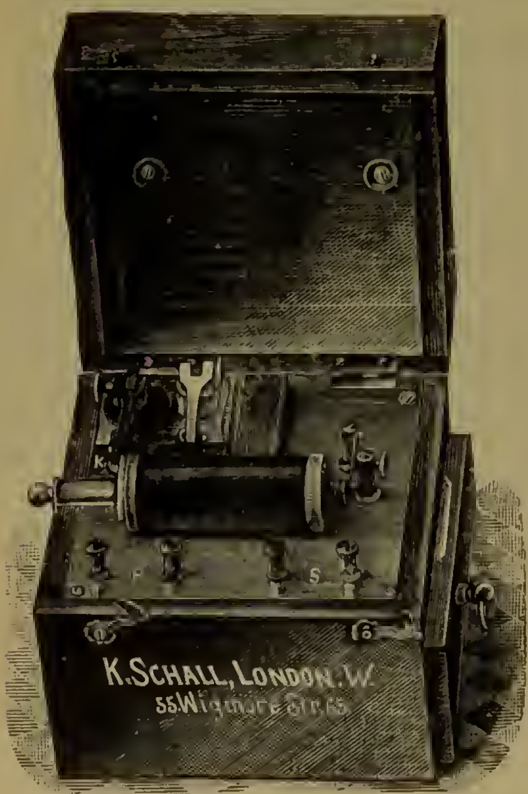

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No. 5A.

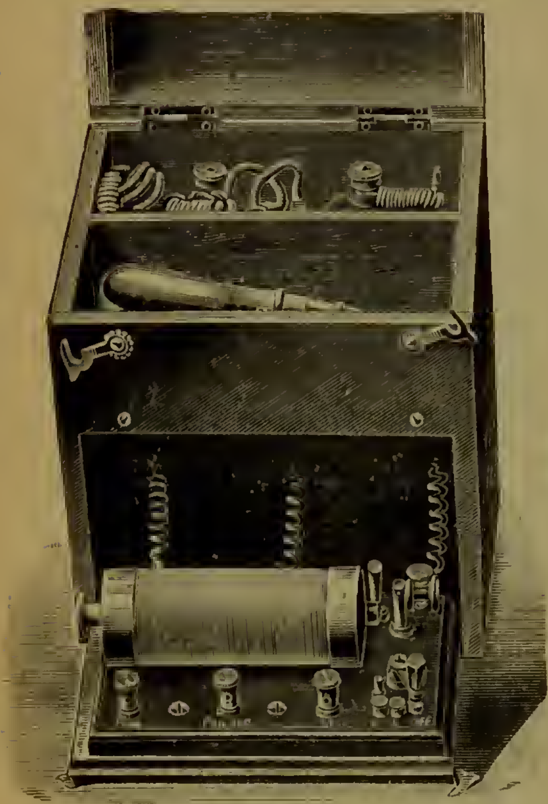
No. 6A.

Coils with Dry Cells.—These coils have the great advantage that there is no acid required to work them. As it is only the spilling of acid which makes a coil go out of order, these coils require practically no repairs and less attention, they are clean, reliable, and convenient. They have been tried now some six years, and have superseded most acid coils (see also page 41). The size and quality of the cells chosen is such, that one cell will work a coil for forty to sixty hours before it gets exhausted. With an average use of ten minutes a day, the cell has to be renewed once in a year. Price of new Cells, including postage, 2/6.

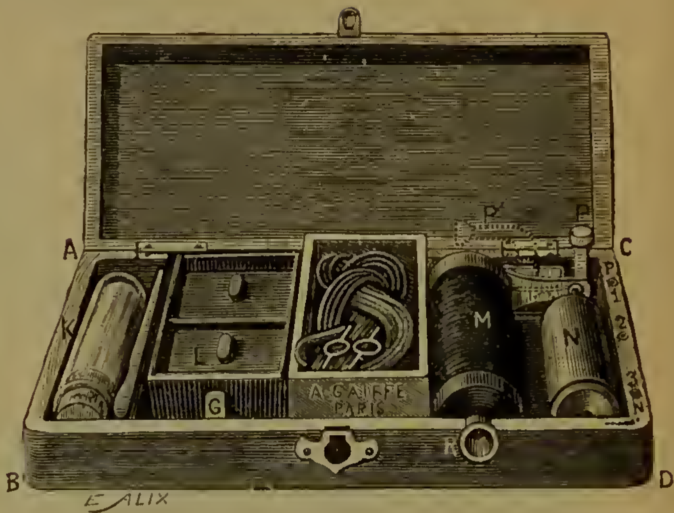
No. 5A.	Same Coil as No. 5, but with dry cell instead of the acid cell, size $5 \times 5 \times 5\frac{1}{2}$ inches, weight $2\frac{3}{4}$ lbs. ...	£1	2	6
No. 6A.	Same Coil as No. 6, but with dry cell instead of the acid cell, size $5 \times 5 \times 5\frac{1}{2}$ inches, weight 3 lbs. ...	2	0	0

This coil is bought more frequently than any other type. It is compact, powerful, and allows a very gradual regulation of the currents strength. It is provided with a good interrupter and a set of six electrodes.

No. 7A. Dr. Spamer's Coil, with two dry cells... ... ... £2 7 6



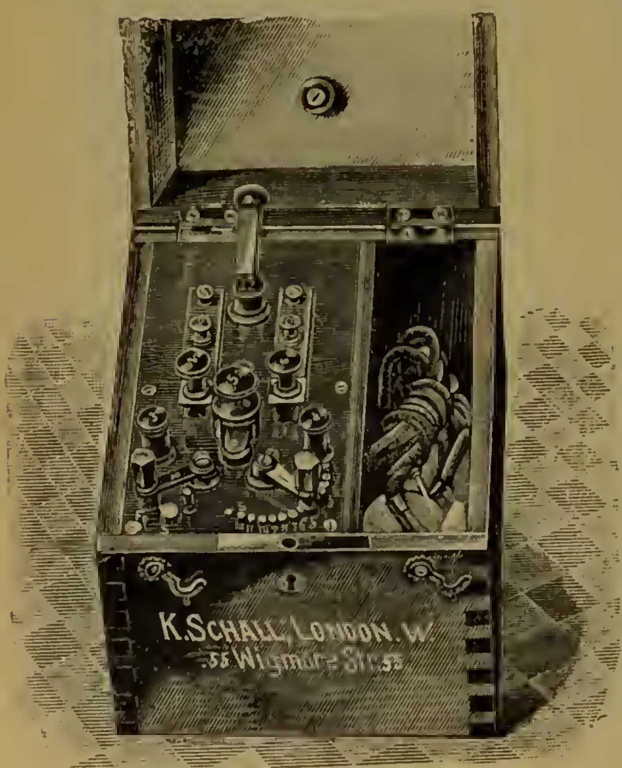
No. 8.



No. 9.

No. 8. Coil, with two *large* dry cells, working the coil for over 100 hours, size 6 × 6 × 7½ inches, weight 5 lbs. £2 2 0

No. 9. Gaiffe's Coil, with two bisulphate of mercury cells, cords, handles, and two electrodes £1 1 0



No. 14.

No. 14. Coil, with large bichromate cell, in polished mahogany case, commutator for primary and secondary current, and crank for regulating the strength of current; cords, handles, and six electrodes ... 2 5 0

Ready-made acid, in bottles with glass stoppers, containing acid for about nine charges, per bottle 0 1 6

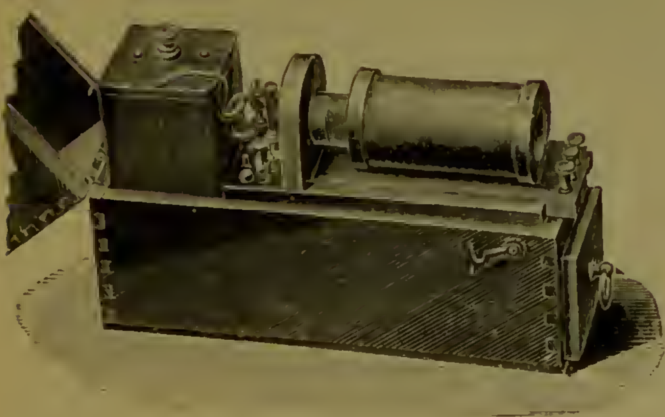
SLEDGE COILS.

If not otherwise ordered, the diameter of the copper wires used in the apparatus Nos. 16—32, is 0·8 millimetre (No. 21 B.W.G.) for the primary coils, and 0·2 millimetre (No. 36 B.W.G.) for the secondary coils, but, if desired, any other size may be used.

No. 16. Dr. Taube's Sledge Coil, with two bichromate cells, 5 × 7 × 5½ inches, weight 4 lbs. **£3 7 0**

No. 16.

No. 17. Dr. Taube's Sledge Coil, with two dry cells **£3 10 0**

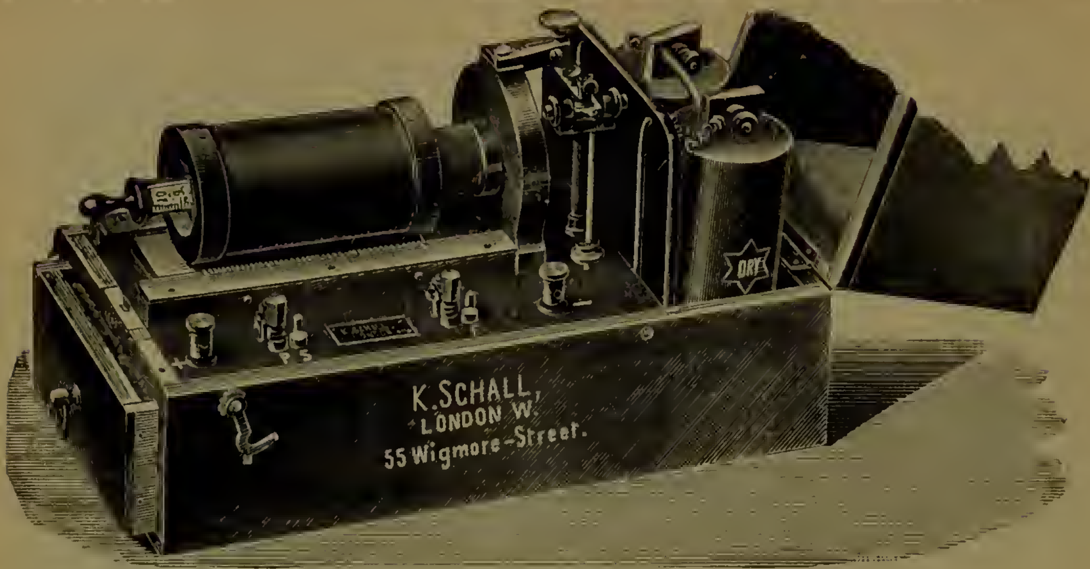


No. 19.

No. 19. Dr. Lewis Jones' Sledge Coil, with one large dry cell, working the coil for about 80 hours altogether ... **£2 0 0**

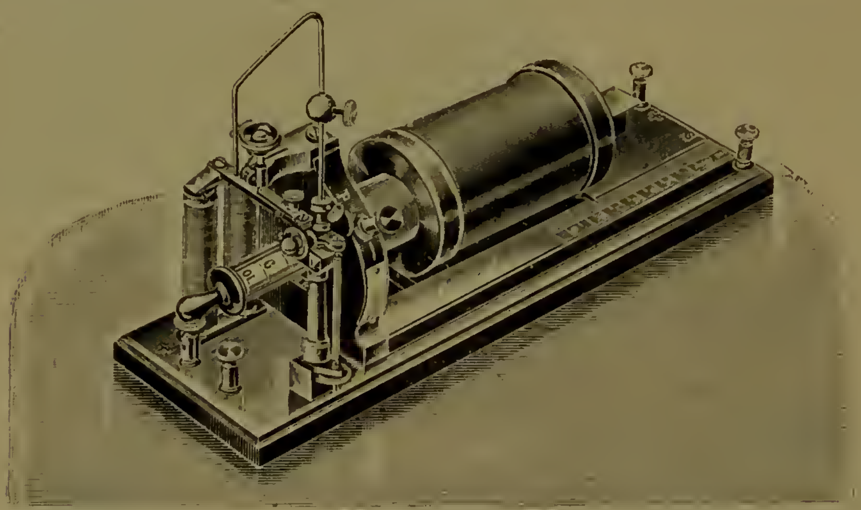
No. 21. Dubois-Reymond's Coil, with two dry cells, in polished mahogany case, commutator for primary and secondary current, cords, handles, and six electrodes, size 5 × 11 × 7 inches, weight 6 lbs., Fig. 21 ... ... **£4 10 0**

This is the most complete and convenient of all the portable coils for diagnosis as well as for treatment. The rapidity of the interruptions may be regulated by means of a weight, which can be fixed higher or lower. The cells will work the coil for more than 80 hours altogether.



No. 21 (see footnote).

Spare Cells for the coils No. 19 and No. 21, 2/6 each.



No. 27.

No. 27. Dubois-Reymond's Coil, with metal scale and adjustable interrupter (for slow or quick vibrations); primary coil 700 turns, secondary coil 5,000 turns £2 16 0

No. 28. The same apparatus, with 10,000 turns on the secondary coil 4 0 0

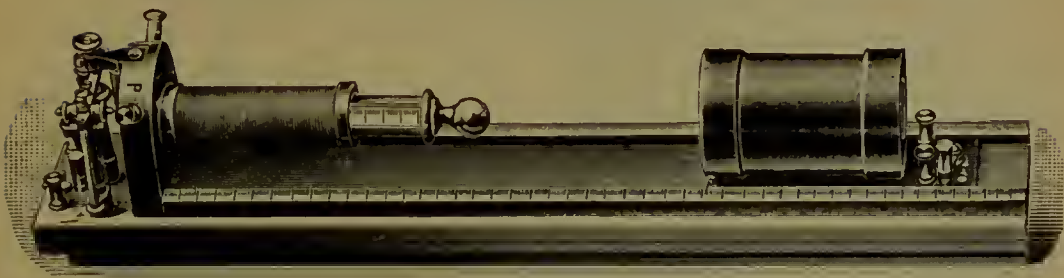
We have supplied coils No. 21, amongst others, to :—

Drs. J. Althaus, Queen Anne Street; Keightley, Queen Anne Street; Sharkey, 22, Harley Street; Head, 61, Wimpole Street; A. Anderson, 37, Wimpole Street; Schorstein, Portland Place; Smith, Nottingham Place; M. Tucker, Harley Street; Knight, Streatham Hill; Routh, Manchester Square; Dickinson, Ealing.

Drs. Winder, Blackpool; Berry, Bournemouth; Scott, Wrotham; Colquhoun, Sandhurst; Warburton, Treherbert; Napier, Glasgow; Major, Bradford; Grant & Durant, Market Harborough; Hall, Leeds; Hamilton, Glasgow; Barlow, Glasgow; Hughes, Brighton; Pendlebury, Ormskirk; Aiken, Fenton; Evans, Cardiff; Peacock, Nuneaton; Playfair, Bromley; Bark, Liverpool; Benthall, Derby.

King's College Hospital, Westminster Hospital, Royal Hospital for Women and Children, Waterloo Bridge Road; Victoria Hospital, Chelsea; Westminster Medical School, Seamen's Hospital, Greenwich; London County Asylum, Claybury; Metropolitan Hospital, Kingsland Road, London; Royal Infirmary, Halifax & Derby; Cottage Hospital, Aberdare; Grimsby District Hospital; Eye Infirmary, Newcastle; Royal Berkshire Hospital, Reading; Children's Hospital, Gloucester; Dispensary, Nottingham; South Charitable Infirmary, Cork; General Infirmary, Hertford, etc., etc.

INDUCTION COILS FOR SPECIAL PURPOSES.



No. 30.

No. 30. Dubois-Reymond's Coil, 4 feet long, with scale and Helmholtz's modification for physiological experiments £4 10 0

(As supplied to University College, King's College, Guy's, Charing Cross, Westminster, and other Hospitals.)

No. 35. Dr. de Watteville's Coil, for primary current only ... 3 5 0

No. 35.

This coil is especially suitable for the electric bath, and for treatment of the abdomen with faradisation. The strength of current is regulated partly by drawing out an iron core, and partly through a crank, by means of which 2, 4, 6, 8 or 10 layers of the copper wire may be thrown in or out of circuit. The number and rapidity of interruptions may be regulated by altering the position of the ball.

No. 40. Schall's Emergency Coil for Operating Theatres, Casualty Wards, etc. £4 4 0

This apparatus (Fig. 40) has been specially constructed for casualty rooms and operating theatres in hospitals, for police stations, life-saving stations, etc., and is so constructed that it requires as little time as possible to set it in action in urgent cases; that persons not accustomed to electric apparatus can work it, and, moreover, it will not easily get out of order nor require repair. It contains either an incandescent lamp—if the electric light is available in the hospital, or else two large dry cells, which, even after standing for years without being used, supply a current strong enough to work the powerful induction apparatus. Two electrodes are permanently connected with the apparatus by means of long and strong cords, so that they have not to be screwed on at the moment of need. The strength of the current can be regulated up to a certain point only by means of a crank, and can be given in seven degrees, the weakest of which even causes pretty strong muscular contractions.

No. 40.

ELEMENTS FOR WORKING COILS.

(See also pages 40 and 41.)

Nos. 50—53.

No. 55.	Dry Leclanché's cell for coils, 5a. 6a. 7a and 17, each	£0	2	6
No. 57.	" " " " 8, 19, 21, 27, 30 & 35 "	0	2	9
No. 60.	Two large Leclanché's cells (dry or liquid) in oak case with terminals	0	14	0
No. 61.	Four " " " " " ...	0	18	6
No. 70.	Bottle bichromate cell, ½-pint ... ... each	0	4	6
No. 71.	" " " 1 " ... ... "	0	7	6
No. 72.	" " " 2 " ... ... "	0	10	0
No. 73.	" " " 4 " (3 carbons and 2 zincs) "	1	0	0
No. 75.	Thermo pile, with gas burner for working coils "	2	7	6

GALVANISATION AND ELECTROLYSIS.

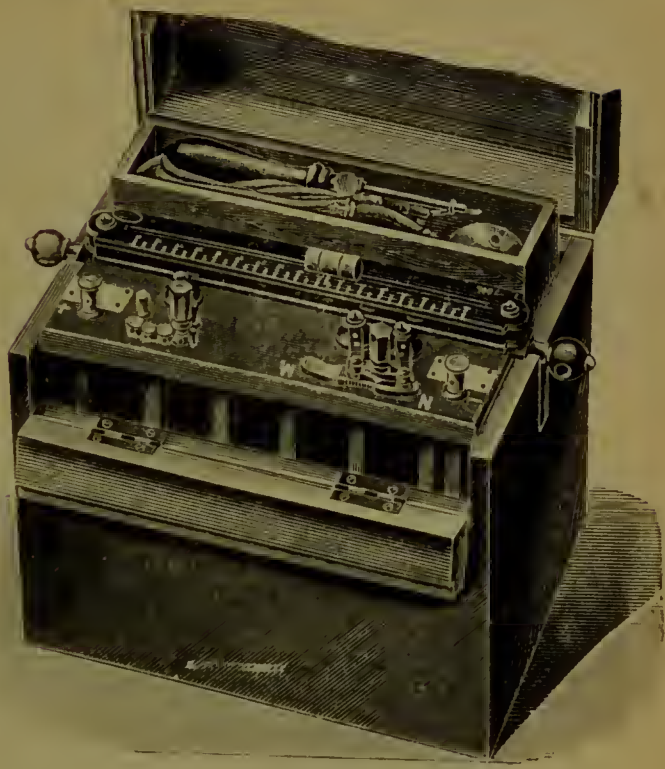
See also pages 10—14.)

PLUNGE BATTERIES.

The special point in these batteries is that the carbons and zincs are cast together, thus ensuring a good connection, since the breaks of contact which not unfrequently occur in elements that are screwed together, cannot possibly happen. Furthermore, when the zincs have been used up, new elements can easily be fixed even by the most inexperienced. India-rubber floats prevent the spilling. During the last ten years over 1,500 of these batteries have been sold, the best proof of their practical construction, and experience has shown that, on account of their great simplicity, they require fewer repairs than any other acid batteries.

These batteries are specially suitable for electrolysis.

No. 80. 24-cell Plunge Battery in polished oak case, with current collector, inserting the cells 8 by 8, current reverser, graphite rheostat, cords, handles and 2 electrodes ... £4 0 0



No. 80.

Plunge Batteries in polished mahogany case, with automatic lifting and lowering arrangement, double collector, current reverser, cords, handles, five electrodes and three spare cells.

No. 90.

No. 86, 24 cells		£7	0	0
No. 87, 32 „		8	10	0
No. 88, 40 „		10	0	0
No. 90, 24 „ with coil		9	0	0
No. 91, 32 „ „		10	10	0
No. 92, 40 „ „		12	0	0
Fitted with galvanometer No. 271	extra	2	15	0
Spare elements for these batteries, 80—92	„	0	0	9
Spare glasses „ „	„	0	0	3

PORTABLE LECLANCHÉ BATTERIES.

If not otherwise ordered, the batteries Nos. 99—140 will be charged with liquid cells, if remaining in or near London, but with dry cells if they have to be sent away a greater distance. Batteries charged with liquid cells can be sent by rail in the care of the guard only. Batteries charged with dry cells can be sent as ordinary freight all over the world.

The recharging of the batteries costs 9d. per cell if they are filled with liquid cells, and 1/9 per cell if they are filled with dry cells.

Provided the batteries are not short circuited, batteries Nos. 99—133 are guaranteed to last with average use for two years before requiring recharging. For combined batteries, the two cells working the coil may require re-charging earlier.

Of the many unsolicited testimonials we have received about batteries Nos. 99—140, we will mention one only. DR. MILNE MURRAY, of EDINBURGH, writes :—"The Combined battery (No. 132) I bought some three or four years ago will soon want re-charging. It has done me splendid service, and I am greatly pleased with it. I have never had any trouble with it, and though I have used it now steadily all these years, and made thousands of applications with it, it is still giving a good current."

Schall's Batteries for Patients and Nurses, in oak cases, with cords, handles, and three electrodes.

The strength of the current can be regulated without giving shocks to the patient, by increasing or diminishing the number of cells (two at a time) by means of the forked cord *a b*.

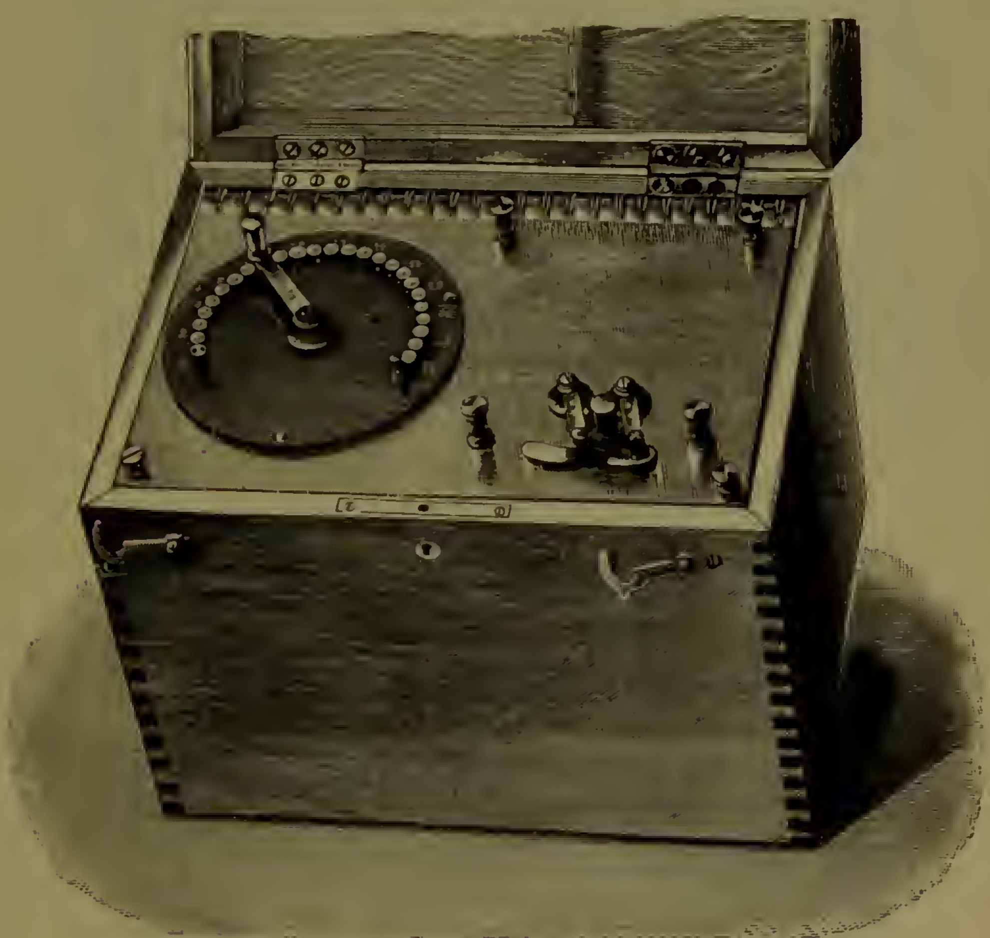
No. 103.

*No. 98.	4 cells	...	...		£0 17 0
*No. 99.	6 „	...	...		1 1 0
†No. 100.	8 „	$3\frac{1}{2} \times 5 \times 6\frac{1}{2}$ inches,	weight 6 lbs.	...	1 12 0
†No. 101.	12 „	$5 \times 5 \times 6\frac{1}{2}$ „	„ $9\frac{1}{2}$ lbs.	...	2 2 0
No. 102.	18 „	$5 \times 9\frac{1}{2} \times 6\frac{1}{2}$ „	„ $12\frac{1}{2}$ lbs.	...	2 15 0
No. 103.	24 „	$7\frac{1}{2} \times 10 \times 6\frac{1}{2}$ „	„ 18 lbs.	(Fig. 103)	3 5 0
No. 104.	32 „	$8 \times 14 \times 6\frac{1}{2}$ „	„ 24 lbs.	...	4 2 0
No. 105.	40 „	$8 \times 17 \times 6\frac{1}{2}$ „	„ 30 lbs.	...	5 0 0

* Suggested by Mr. Cardew, for treating exophthalmic goître. (Graves's disease.)

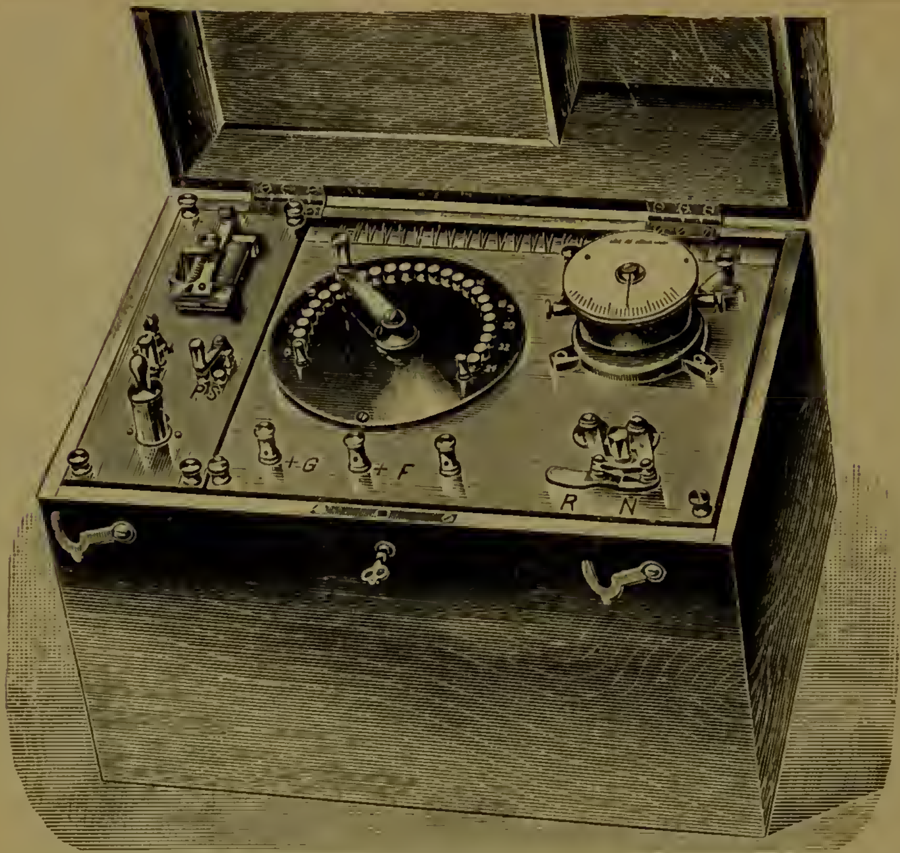
† For throat, ear, and eye diseases, for removing hairs by means of electrolysis, etc.

Schall's Batteries, with current collector, current reverser, cords, handles, and four electrodes (oak case).



No. 117.

No. 116,	18 cells,	$4\frac{1}{2} \times 9\frac{1}{2} \times 11$ inches,	weight 16 lbs.	...	£4 10 0
No. 117,	24 „	$7 \times 11 \times 11$ „	„ 21 lbs.	(Fig. 117)	5 10 0
No. 118,	32 „	$7 \times 13\frac{1}{2} \times 11$ „	„ 29 lbs.	...	6 12 0
No. 119,	40 „	$7 \times 7 \times 11$ „	„ 37 lbs.	...	7 12 0



No. 117A.

Schall's Combined Batteries.—With current collector, current reverser, coil No. 6A, and large dry cell, cords, handles, and 5 electrodes. The galvanometer shown on illustration is 30/- extra.

No. 116A, 18 cells		£6	10	0
No. 117A, 24 ,, (Fig. 117A)		7	10	0
No. 118A, 32 ,, ...		8	12	0
No. 119A, 40 ,, ...		9	12	0

No. 124.

Schall's Batteries, with double collector, current reverser, galvanometer (No. 270 or No. 271), cords, handles, and five electrodes.

No. 122, 24 cells,	7 × 11 × 11 inches, weight	22 lbs. ...	...	£10 0 0
No. 123, 32 „	7 × 13½ × 11 „ „	30 lbs. ...	...	11 0 0
No. 124, 40 „	7 × 16 × 11 „ „	38 lbs. (Fig. 124)		12 0 0
No. 125, 50 „	8½ × 16½ × 11 „ „	47 lbs. ...	...	13 0 0

No. 132.

Schall's Combined Batteries, with double collector, current reverser, galvanometer No. 271, coil No. 27, Dr. de Watteville's commutator, cords, handles, and seven electrodes.

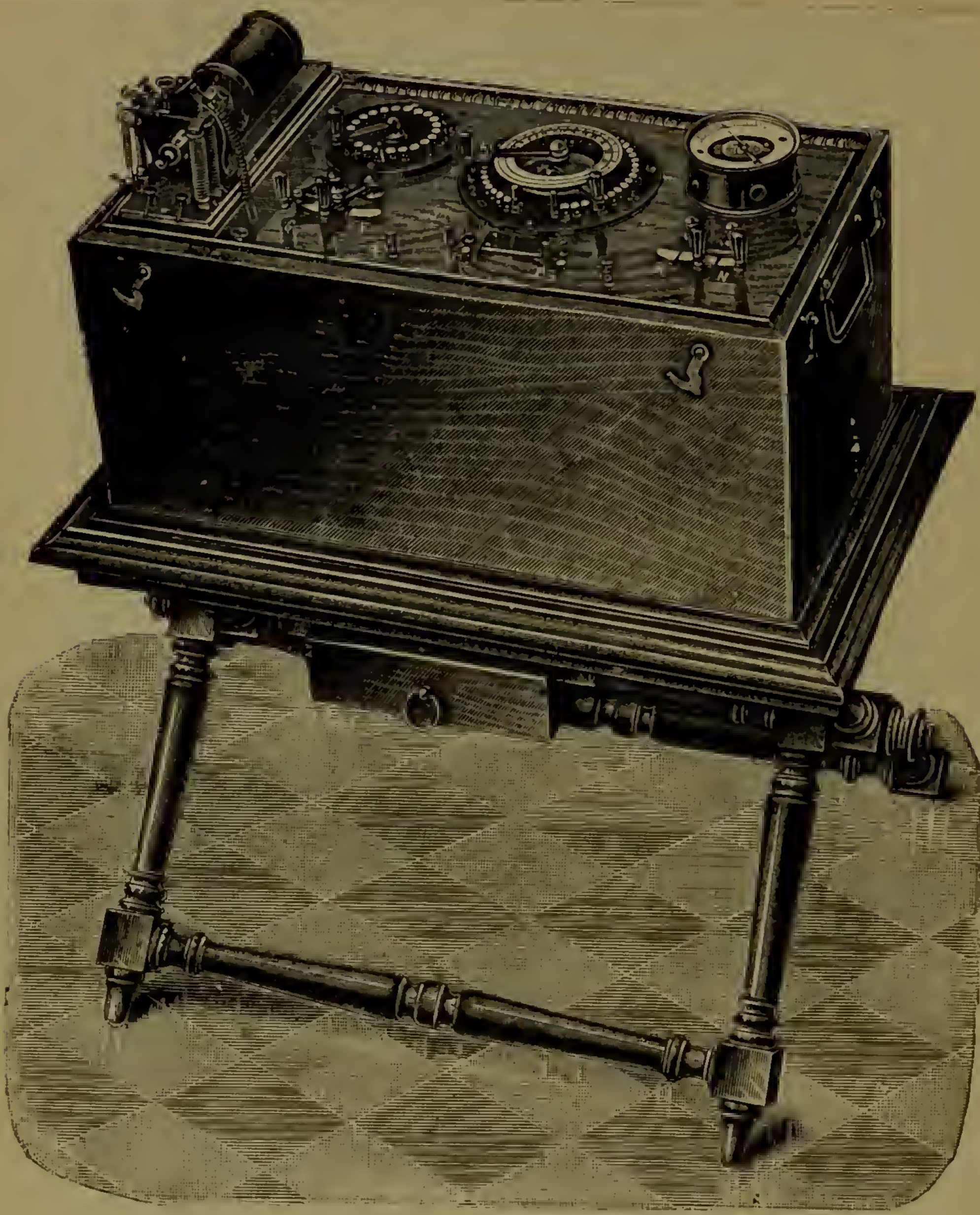
No. 130.	24 cells, 7 × 13 × 11 inches, weight	34 lbs. ...	...	£12 15 0
No. 131.	32 „ 7 × 15½ × 11 „ „	42 lbs. ...	...	14 10 0
No. 132.	40 „ 9 × 16½ × 11 „ „	48 lbs. ...	...	16 5 0
No. 133.	50 „ 10½ × 16½ × 11 „ „	57 lbs. ...	...	18 0 0

To save space, the Coil No. 27 is arranged vertically in the batteries 130—133, but, if preferred, it can be mounted in the same manner as Fig. 139 shows, without alteration in price.

Schall's Combined Batteries, larger size, with double collector, current reverser, galvanometer No. 270 or No. 271, coil No. 27, Dr. de Watteville's commutator, cords, handles, and nine electrodes.

No. 137.	32 cells	... ...	£16 0 0
No. 138.	40 „	12 × 23 × 14 inches	18 0 0
No. 139.	50 „	(Fig. 139)	20 0 0
No. 140.	60 „	... .	22 0 0

The addition of a rheostat (No. 310) increases the price of the batteries by £1 each.



No. 139.

These batteries are excellent for consulting rooms, hospitals, etc., for galvanisation, electrolysis, faradisation, and for lighting small lamps. They contain all the necessary accessories for measuring the strength of current, the E.M.F. of the cells and the resistance of the patient.

No. 142. Stand, with drawer for the reception of the electrodes, and two movable shelves, to put a water basin, etc., on **£3 9 0**

There are several hundred of our Leclanché batteries 123—140 in use already. They have been supplied, amongst others, to—

Drs. Lauder Brunton, Nunn, Stratford Place; Andrew Clark, T. Little, T. James, W. Cheyne, S. Sharkey, Harley Street; Maddick, Pasteur, Chandos Street; Mott, H. Bennett, Sir F. Semon, Hood, Lewis Jones, Wimpole Street; Mason, Pitt, Turney, Schorstein, Bridger, Portland Place; Mont. Murray, Jackson, Routh, Manchester Square; Scanes Spicer, Welbeck Street; Hedley, Mansfield Street; J. Althaus, Queen Anne Street; Juler, Cavendish Square;

Buzzard, Grosvenor Street; Broadbent, Seymour Street; Morrison, Cadogan Place; Harvey, Astwood Road; Skinner, York Place; Cosens, Oxford Terrace; Warner, Brechin Place; Currie, Queen's Road, ; Manley Sims, Hertford Street; Holmes, Old Burlington Street; Beauchamp, Cromwell Road; Goldsborough, Welbeck Street.

Lord Kelvin, Dr. Macintyre, Glasgow; Drs. Milne Murray, Taylor, Turner, Ronaldson, Bruce, Haultain, Edinburgh; Aldous, Plymouth; Armstrong, Buxton; Brown, Hayward, Wilson, Liverpool; Cremon, Cummins, Pearson, Cork; Griffith, Swansea; Griffith, Hayward's Heath; Green, Sandown; Cross, Clifton; Battersby, Cannes; Barron, Ascot; Beatty, Clacton-on-Sea; Friel, Waterford; Greenbury, Bradford; Mason and Bridgman, Burton-on-Trent; Moberley, Bridlington Quay; Nicol, Llandudno; Passmore, Gainsborough; Reid, Canterbury; Russel, Burslem; Richardson, Croydon; Rayner, Malvern; Renney, Sunderland; Rendall, Mentone; Roderick, Llanelly; Powell, Exmouth; Shelly, Hertford; Surridge, Knutsford; Smith, Ingatestone; Thomas, Bromley; Winder, Blackpool; White, Leeds; Wood, Woolpit.

Guy's Hospital, St. Mary's Hospital, St. Thomas's Hospital, London Hospital, National Hospital for Diseases of the Heart, Central Ear and Throat Hospital, General Dispensary, Marylebone; London County Lunatic Asylum, Hanwell; St. Andrew's Home, Folkestone; Dispensary, Exeter; Devon and Exeter Hospital, Exeter; Withworth Hospital, Mater Misericordia Hospital, Dublin; Royal Infirmary, Hospital for Sick Children, Aberdeen; Manchester Southern Hospital; Infirmaries in Macclesfield, Dundee, Downpatrick, Greenock, Waterford, and Worcester; County Asylum, Whittingham; Haywood Hospital, Burslem; Addinbrooke Hospital, Cambridge; Grimsby District Hospital; Sidmouth Hydropathic Co.; Hazelwood Hydropathic Co.; St. Anne's Hill Hydropathic Co., Cork, etc., etc.

No. 143. Trolley, for hospital use (Illustration on application)... **£3 5 0**

For apparatus for utilizing the current supplied from dynamos for galvanisation, electrolysis and faradisation, see pages 130–144.

STATIONARY BATTERIES.

For physicians who have to apply electricity frequently, and whose batteries need not be portable, as well as for hospitals and other establishments, etc., the stationary batteries have great advantages, because cells of large type can be used for them. They are more constant than the small cells used for portable batteries, and last on an average for three years without requiring re-charging, or any other repairs whatever. (The cells working the induction coil may require re-charging oftener, if strongly used.)

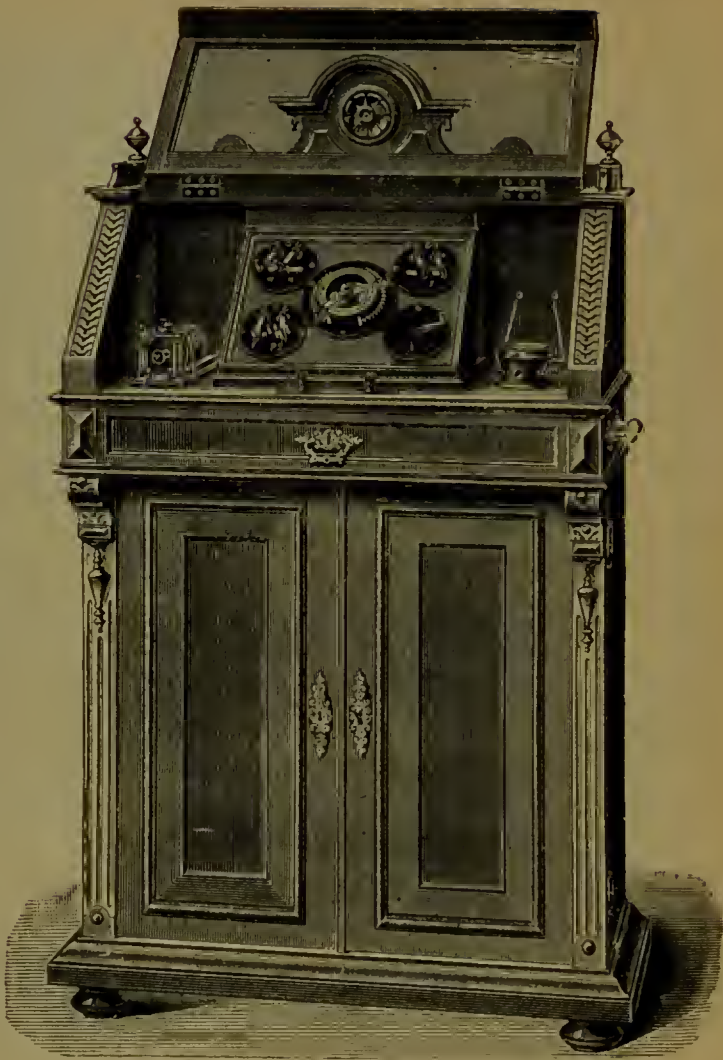
(As to the cells used for these batteries, see also page 11.)

The batteries Nos. 160—180 may be used for surgical lamps requiring not more than 0·8 ampère.

No. 160. 44 Leclanché cells, in oak cabinet, (Fig. 170), double collector, galvanometer No. 277, cords, handles, and six electrodes £25 0 0

No. 162. The same battery, but with coil No. 27, commutator for primary and secondary current, and Dr. de Watteville's commutator in addition £30 0 0

No. 170 44 Leclanché cells, in oak or walnut cabinet, with double collector, galvanometer No. 278, rheostat No. 321, current interrupter and current reverser, coil No. 27, Dr. de Watteville's commutator, cords, handles, and nine electrodes £37 0 0



No. 170.

(As supplied to St. Mary's Hospital, Dr. E. Blake, Mr. Victor Horsley, Sir Russell Reynolds, Dr. Lloyd Roberts, Dr. M. M. Sharpe, Dr. C. H. Haines, Mr. Tucker, Dr. Lauder Brunton, Dr. Gamgee, Dr. Macvail. Dr. Macintyre, Dr. Levellyn, Dr. Knight, Dr. Bachelor, Western Infirmary, Glasgow ; Dr. Hamilton, New York ; and others.)

Batteries Nos. 160, 162, and 170, with 50 cells instead of 40, each extra £3 0 0

" " " " " 60 " " " " 6 0 0

No. 175. 60 Leclanché cells, in carved oak cabinet, with double collector, Brenner's current breaker and current reverser, graphite rheostat, galvanometer No. 290, large coil No. 28, and Dr. de Watteville's commutator, handles, cords, and nine electrodes 48 0 0

Nos. 160 to 180 are the most frequently used combinations of apparatus. There are, however, many other combinations possible. The apparatus can be fixed on tables instead of on cupboards, or can hang on the wall in order to take up less room. We are prepared to meet the wishes of medical men as to special combinations, size and shape, to send estimates and photographs.

ELECTRIC BATH.

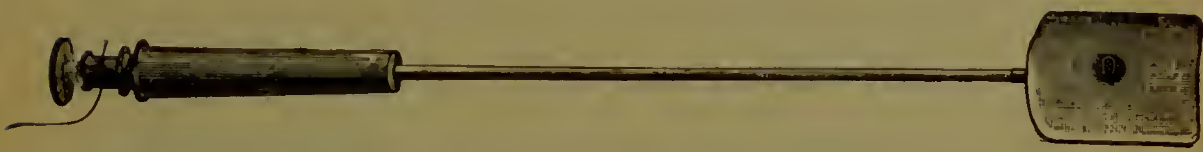
Any wooden or porcelain bath tub is fit for an electric bath. Metal tubs may be insulated to a certain extent by means of bath enamels, so that the electric current can therein be applied to the patient. Tin electrodes, about ten inches square, are immersed in the water at the upper and lower ends, sometimes at both sides as well, or else the electrodes shown in Nos. 195 to 198 can be used.

No. 195. Large bath electrode £0 12 6

No. 196. The same, bent for the head or foot end of the tub 0 15 0

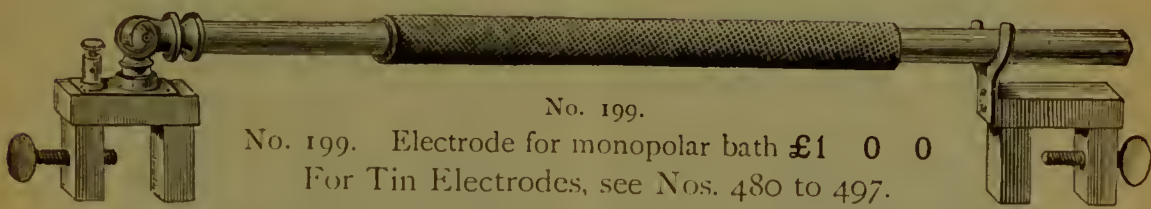
No. 195.

No. 196.



No. 198.

No. 198. Paddle Electrode £0 9 0



No. 199.

No. 199. Electrode for monopolar bath £1 0 0

For Tin Electrodes, see Nos. 480 to 497.

In this way any bath tub can, without trouble or serious expense, be made fit for the treatment of a patient with the electric current. The Induction Coil No. 35 is specially recommended, if the Faradic current is used. The Batteries Nos. 116 to 140, or Nos. 160 to 192 are suitable for applying the Galvanic, Faradic, or Combined currents.

For complete Electric Baths in hydropathic establishments or in hospitals, we recommend a specially constructed Bath Tub, at the bottom and sides of which six or eight electrodes are fixed, so that the patient does not come in contact with them. A commutator makes it possible to make the Galvanic, Faradic, or Combined current circulate between any pair of electrodes.

If it is desired, the douch may be connected with the current, and be applied as one pole or electrode.

The battery and commutator can be placed in the same room as the bath, or in an adjacent room. In either case complete control over the direction and strength of the current in the bath is possible. The commutator has to be connected with the bath tub by as many wires as there are electrodes in the bath.

No. 205. Oak Bath Tub, with eight fixed electrodes and commutator £12 10 0

The price of a complete installation of an Electric Bath with extra tub is £17 to £50; without special bath tub from £4 to £40, according to the battery chosen.

Estimates and Photographs will be sent on application.

CURRENT COLLECTORS, REVERSERS, COMMUTATORS, &c.

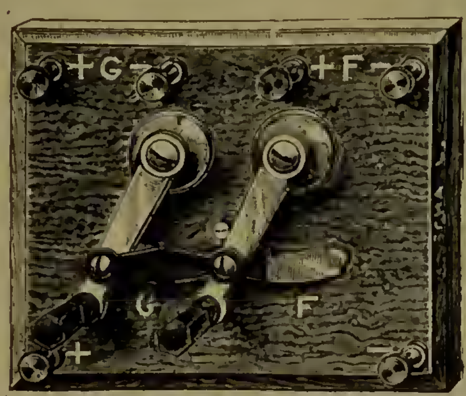
(See also pages 14—19.)

No. 209. **Schall's Double Collector,** mounted on polished ebonite, for 20 cells . £1 18 0

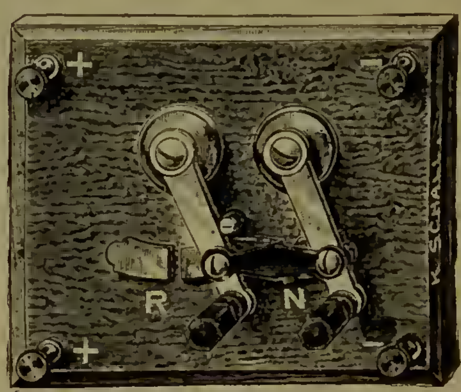
No. 210.	30 cells	..	2	5	0
No. 211.	40 ,,	..	2	14	0
No. 212.	50 ,,	...	3	3	0
No. 213.	60 ,,	...	3	10	0

No. 210.

No. 222. **Current Reverser and Interrupter,** mounted on polished board £0 14 0



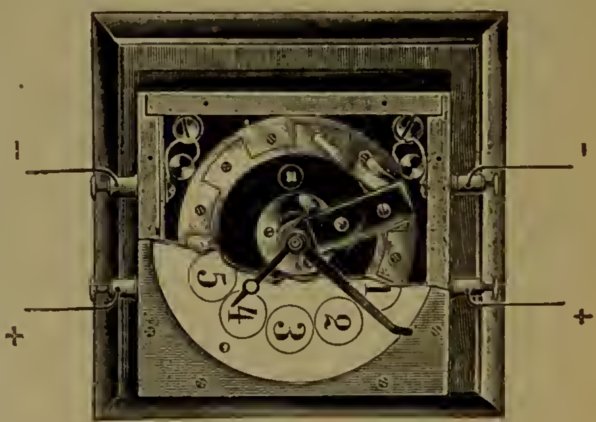
No. 232.



No. 222.

No. 232. Dr. de Watteville's commutator, for the use of Galvanic, Faradic, or Combined currents £0 16 0

No. 236. Dr. Meissner's current reverser. This instrument reverses the current automatically every five minutes (for cataphoresis), £2 15 0



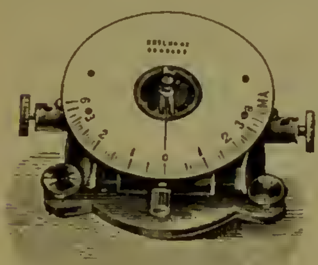
No. 236.

GALVANOMETERS.

(See also pages 15—18.)

The instruments Nos. 264—275 are called *pocket galvanometers*, because they are provided with a cover, so as to be easily portable. The magnets oscillate inside a solid copper block, to make the instruments dead beat. If the point on which the needle oscillates has become blunt, this point—which consists of an ordinary sewing needle, No. 10—can easily be taken out and replaced by a new needle by anybody. The new needle should project just as far as the old one did when the galvanometer was being graduated, or else the division would become inaccurate. To get the correct projections of the needle, the galvanometers 264—272 are provided with a black T-shaped gauge. It is held against the horse shoe and the new needle is fixed in such a position, that its point just touches the top of the gauge.

The galvanometers Nos. 264—275 are divided to meet the horizontal intensity of London, and the greatest error is guaranteed not to exceed 2 per cent.

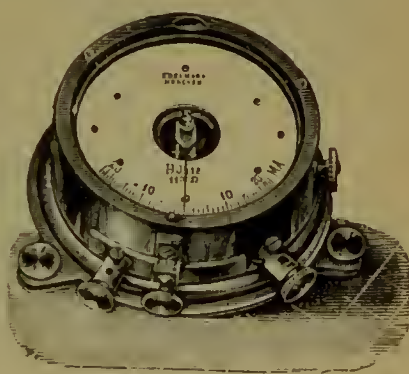


No. 264.

No. 264. Edelmann's galvanometer, in cardboard box, showing up to 6 milliampères each $\frac{1}{10}$th part of a milliampère £1 10 0

No. 265. The same instrument, showing up to 30 milliampères, each single milliampère 1 10 0

No. 270. Dr. Edelmann's galvanometer, in polished mahogany box, showing up to 5 milliampères every $\frac{1}{10}$th part of a milliampère; or by using the shunt, each single milliampère up to 50 milliampères £2 16 0



No. 271.

No. 271. The same instrument, showing each single M.A. up to 25, or by using the shunt, every 10 milliampères up to 250 M.A. £2 16 0

No. 272. The same instrument, with two shunts, showing up to 5, 50 or 500 milliampères 3 10 0

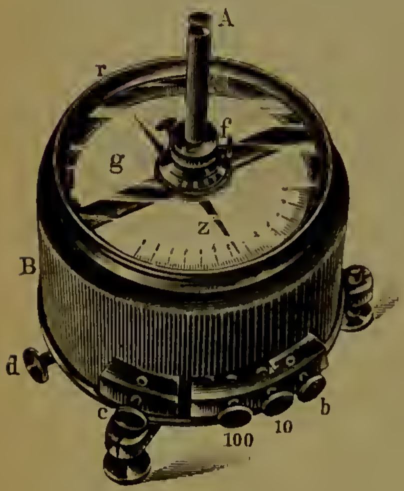
No. 273. Floating galvanometer, showing up to 300 M.A. 2 10 0

No. 274. Milliampère meter for *alternating* currents, showing up to 300 M.A. 4 4 0

GALVANOMETERS WITH MAGNET SUSPENDED ON COCOON.

No. 277. Galvanometer, with two shunts, showing up to 5, 50, or 500 milliampères £4 10 0

No. 277.



No. 278.

No. 278. Dr. Edelmann's Universal galvanometer £7 12 0

Nos. 277 and 278 indicate every $\frac{1}{10}$th part of a milliampère from 0 to 5. each single milliampère from 0 to 50, and 10 by 10 milliampères from 0 to 500 milliampères.

No. 279. The same instrument, but with an additional resistance, allowing the instrument to be used also as a voltmeter £8 16 0

In order to read horizontal galvanometers more conveniently, instruments Nos. 270—279 can be supplied with a mirror, fitted to a movable ring

No. 281. Mirror for the instruments Nos. 270—275 £0 12 0

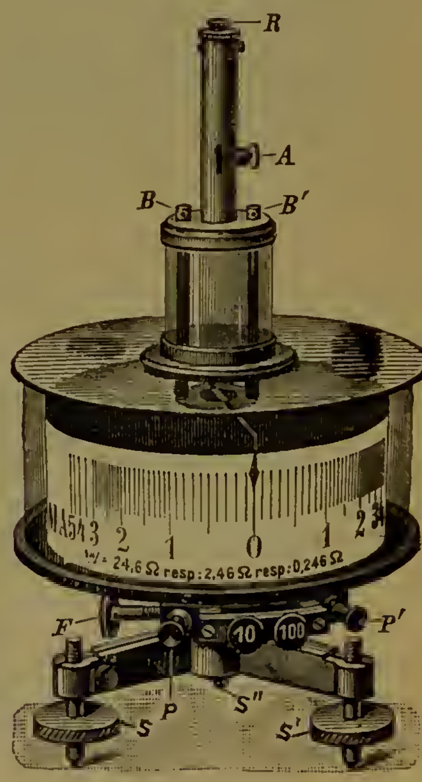
No. 282. Mirror for the instruments Nos. 278 and 279 ... ... 0 18 0

No. 290. Large horizontal galvanometer, with vertical scale 10 10 0

No. 292. The same instrument with voltmeter ... 11 15 0

The internal arrangement, accuracy, etc., of this apparatus are exactly the same as in No. 278. The scale, protected by a glass cover, has, however, a diameter three times larger, in consequence of which the divisions are much more distinct, and can be read at a distance of some yards. The instrument is not portable, and is best placed upon a zinc bracket, fixed to the wall, in a good light and convenient position. It shows up to 5 M.A.'s, each $\frac{1}{10}$th part of a M.A., up to 50 M.A.'s, each single M.A., and 10 by 10 M.A.'s up to 500 M.A.'s.

No. 294. Zinc Bracket for same 18/-



No. 290.

No. 295.

No. 295. D'Arsonval galvanometer, with two shunts showing up to 5 M.A. every $\frac{1}{10}$th part of a M.A. up to 50 every single M.A. and up to 500, 10 by 10 M.A. (Fig. 295) **£4 0 0**

These instruments are independent of the earth's magnetism, and can be used in a horizontal, vertical, or any other desired position.

RHEOSTATS.

(See also page 15.)

GRAPHITE RHEOSTATS.

No. 306. Rheostat with Mercury contact, total resistance about 100,000 ohms, which can be diminished *gradually*, without any jumps, down to about 20 ohms by turning the glass dial ... **£1 17 0**

No. 306.

Nos. 308—319.

Rheostats with sliding spring; the resistances can be varied *gradually*, without any jumps.

No. 308.	From	3 to	200 ohms	... .	£0	18	0
No. 309.	,,	5 to	600 ,,	.. ..	0	18	0
No. 310.	,,	5 to	1,000 ,,	... ...	0	18	0
No. 311.	,,	10 to	5,000 ,,	... ...	0	18	0
No. 312.	,,	25 to	10,000 ,,	... ...	0	18	0
No. 313.	,,	50 to	25,000 ,,	... ...	0	18	0
No. 314.	,,	50 to	50,000 ,,	... ...	1	0	0
No. 315.	,,	100 to	75,000 ,,	... .	1	0	0
No. 316.	,,	100 to	100,000 ,,	... ...	1	0	0
No. 319.	,,	500 to	1,000,000 ,,	... ...	1	5	0

No. 320.

No. 320. Several of these rheostats can be mounted on a board, and be connected in series, so as to have, for instance, one rheostat with a low, one with a medium, and one with a high resistance. Price of the board, with 3 rheostats, including terminals and connections £2 12 0

METAL RHEOSTATS.

No. 320.

No. 321.

No. 320.	1,000 ohms, in 26 sub-divisions	£2 16 0
No. 321.	5,000 ohms, in 30 sub-divisions	3 12 0
No. 325.	Large metal rheostat, with 2 cranks, with 21,000 ohms total resistance, in 70 sub-divisions	6 0 0

The number of ohms indicated on these metal rheostats is only approximately correct (within 10 per cent.), but the 1,000 ohms are correct, so that the rheostats can well be used for measuring the E.M.F. of batteries.

CONNECTING CORDS.

No. 329.	12 yards insulated copper wire	1/6
No. 330.	One pair of cords, for galvanisation, faradisation, or electrolysis, covered with silk, 1½ yards long	3/0
No. 332.	Ditto ditto 2 „	3/6
No. 336.	Separate terminals to be attached to silk cords ... each	0/6

ELECTRODES.

No. 365.	Handle for the reception of large sponges, diameter 4 inches, for general galvanisation and faradisation, without sponge	7/0
No. 366.	Ditto ditto ditto with sponge	10/0

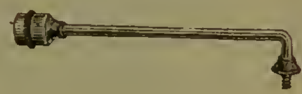
The sponges can easily be exchanged in Handle No. 365.


No. 372.

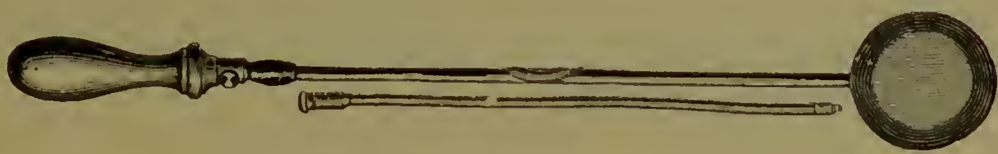

No. 376.

No. 370.	Simple handle, 3 inches long	1/6
No. 371.	,, 4 ,, ...	2/6
No. 372.	,, 5 ,, ...	3/0
No. 376.	Handle for *interrupting* the current, 5 inches long	5/0
No. 377.	,, ,, ,, 6 ,, ...	5/0
No. 378.	,, ,, ,, for throat electrodes ...	6/0

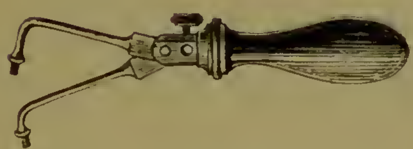

No. 381.


No. 385.

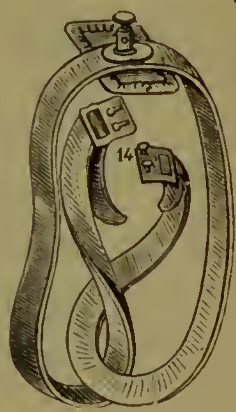
No. 381.	Handle for *making* the current, 5 inches long	5/0
No. 382.	,, ,, ,, 6 ,, ...	5/0
No. 383.	,, ,, ,, for throat electrodes... ...	6/0
No. 385.	Connecting piece for fixing the electrodes at a right angle to the handles, Fig. 385	2/0


No. 398.

No. 398.	Handle, with long insulated shaft, for introducing electrodes under the clothes	9/0


No. 400.


No. 412.



No. 418.

No. 400.	Double handle, by Dr. Althaus	10/0
No. 412.	Bracelet for fixing electrodes to the arms or wrists	4/6
No. 418.	Belt electrode, by Beard and Rockwell	6/0

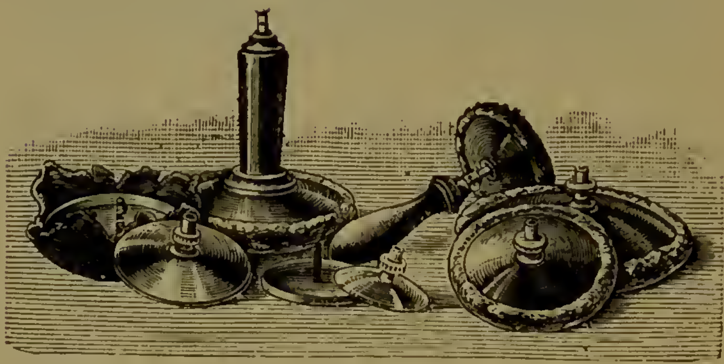
Nos. 430—32.

Nos. 442—49.

No. 430.	Button shape electrodes, small...	1/3
No. 431.	,, ,, ,, medium	1/6
No. 432.	,, ,, ,, large	1/6

Round Tin Plates, covered with leather.

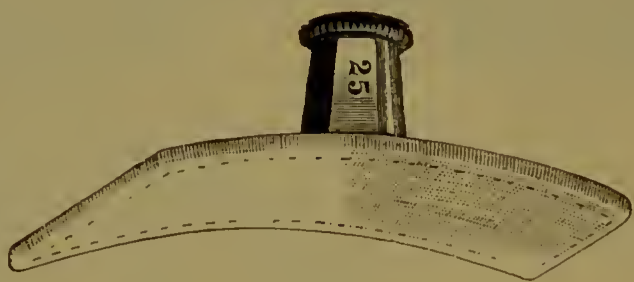
No. 442.	$\frac{3}{4}$ inch diameter ...	1/4	No. 445.	2 inches diameter ...	2/0
No. 443.	1 ,, ,, ...	1/6	No. 447.	3 ,, ,, ...	2/9
No. 444.	$1\frac{1}{2}$,, ,, ...	1/9	No. 449.	4 ,, ,, ...	4/0



Nos. 452—58.

Round electrodes, of aluminium, with stout handles, and an arrangement allowing the flannel, leather, amadou or sponge cover to be easily exchanged.

No. 451.	1 inch diameter ...	3/6	No. 454.	3 inches diameter...	5/0
No. 452.	2 ,, ,, ...	4/0	No. 458.	5 ,, ,, ...	7/6



Nos. 460—70.

Square flexible electrodes, of tin, with leather covers.

No. 460.	1 square inch ...	1/6	No. 466.	6 square inches ...	3/0
No. 462.	2 ,, inches ...	1/9	No. 468.	8 ,, ,, ...	3/9
No. 463.	3 ,, ,, ...	2/0	No. 469.	10 ,, ,, ...	4/0
No. 464.	4 ,, ,, ...	2/3	No. 470.	12 ,, ,, ...	4/6

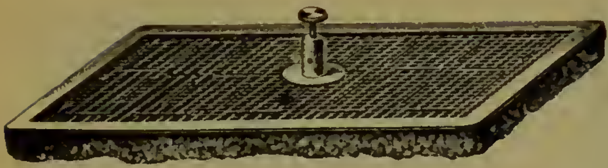
Nos. 441—449 and 460—470, with carbon plates and leather cover, 50 per cent. more.

No. 475. Electrode for neck, covered with wash leather 4/6

No. 475.

Flexible tin electrodes, with white flannel covers and terminals, back of the electrode covered with wax cloth (see illustration No. 103, page 76).

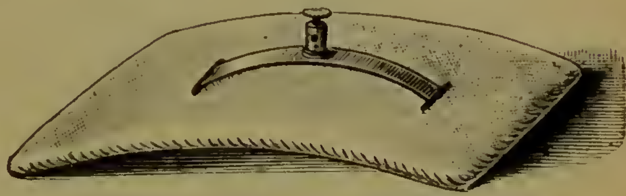
No. 480.	$2\frac{1}{2} \times 4$ inches ...	1/3	No. 491.	$3\frac{3}{4} \times 7$ inches ...	2/3
No. 483.	$2\frac{3}{4} \times 5$,, ...	1/6	No. 493.	$4\frac{1}{2} \times 8\frac{1}{2}$,, ...	2/6
No. 486.	$3 \times 5\frac{1}{2}$,, ...	1/6	No. 495.	$5 \times 8\frac{1}{2}$,, ...	3/0
No. 489.	$3\frac{1}{2} \times 6$,, ...	1/9	No. 497.	6×10 ,, ..	4/0



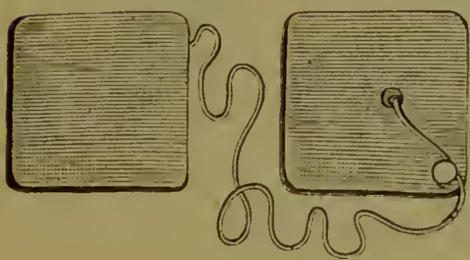
Flexible metal gauze electrodes, with sponge, according to sizes, 5/0 to 12/0

No. 500.

Large indifferent electrode 5/0



No. 510.



Nos. 520—21.

Nos. 525—28.

No. 520.	Foot plate electrode, with flannel cover and terminal,	100 square inches	7/6
No. 521.	Ditto ditto	130 ,, ,,	8/6
No. 525.	Flexible pillow electrodes, Fig. 525	70 ,, ,,	10/0
No. 526.	,, ,, ,,	100 ,, ,,	12/0
No. 528.	,, ,, ,,	140 ,, ,,	14/0

These electrodes are filled with small pieces of carbon, they do not get blackened on the outside, and being very flexible, cling closely to any part of the body. They are well adapted for Dr. Apostoli's method.

Nos. 540—42.

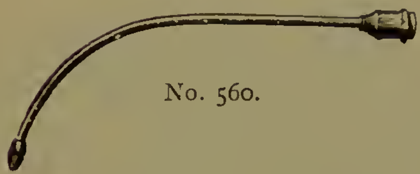
No. 545.

Brush electrodes with metal wire, without handles.

No. 540.	Small	1/6	
No. 541.	Medium	1/9	
No. 542.	Large	2/6	
No. 545.	$2\frac{1}{2}$ square inches ...	5/6	
No. 550.	7 ,, ,, Fig. 550	8/6	
No. 555.	Double brush, 9 square inches, Fig. 555...	10/0	

No. 550.

No. 555.



No. 560.

No. 572.

No. 560.	Electrodes for larynx, with olive shaped button, shaft insulated with gutta-percha	2/6
No. 566.	Electrode for stomach...	9/6
No. 568.	,, for cervix, 3 sizes ... ... each	6/6
No. 570.	,, for rectum ,, ... ,,	4/6
No. 572.	Zinc electrodes for rectum	3/0

No. 573.

No. 573.	Electrode for rectum, with douche	6/0
No. 575.	Electrode for bladder	3/0
No. 580.	Mr. Cardew's bladder electrode, with ebonite tap and soft catheter	8/0

No. 585.

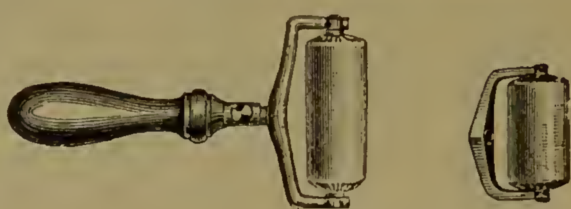
No. 586.

No. 589.

No. 585.	Electrode for the ear	6/0
No. 586.	Dr. Weber Liel's electrode for the ear ...	6/0
No. 588.	Electrode for the eye ...	9/6
No. 589.	Spinal electrode ...	4/0

No. 588.

No. 590.



Nos. 600—603.

No. 590.	Electrode for penis	7/0
No. 600.	Wheel electrode, $1\frac{1}{2}$ inch long, without handle	4/6
No. 602.	,, ,, $2\frac{1}{2}$ inches long	5/6
No. 603.	,, ,, $3\frac{1}{2}$,, ...	7/0
No. 604.	Double wheel electrode, with handle	16/0

No. 604.

No. 610.

No. 610. Glass vessel for holding various liquids (unpolarisable or diffusion electrode) ... ... 1½ inch diameter 6/0

No. 612. Ditto ditto ditto 2½ inches ,, 7/0

No. 615.

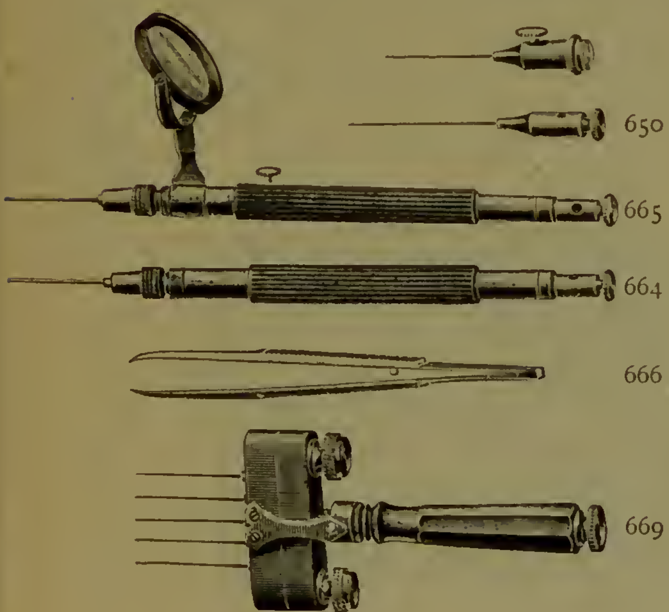
No. 620.

No. 615. Dr. Meissner's double electrode for cataphoresis, Fig. 615 ... 16/0

No. 620. Dr. de Watteville's electrode for testing sensibility, with 200 separate wires 9/0

ELECTRODES FOR ELECTROLYSIS AND FOR THE TREATMENT OF STRICTURES.

Needles for removing hairs, nævi, and small tumours.



No. 675.

No. 650. Steel Needle with terminal 1/6

No. 657. Platinum Needle with terminal 2/6

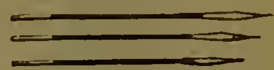
No. 660. Gold Needle 3/0

No. 663. Lens as shown in Fig. 665, for magnifying the hairs—it can easily be attached to our needle holders 664 or 665 ... 6/0

No. 664.	Needle Holder for the reception of different needles, Fig. 664	3/6
No. 665.	Needle Holder with interrupter ... ... ,, 665	4/0
No. 666.	Forceps for epilation ... ... ,, 666	2/6
No. 668.	25 Steel Needles (No. 12)	0/6
No. 669.	Dr. Lewis Jones' Multiple Bi-polar Needle Holder, for treatment of nævi ... ... Fig. 669	15/0

No. 675. Complete set for epilation, consisting of 9-cell battery with collector inserting the cells one by one (see illustration 675), bracelet electrode No. 412, needle holder No. 664, forceps No. 667, a packet of needles and connecting wires £3 6 0

Needles for destroying tumours, etc., with flat platinum points, and shafts insulated with india-rubber.



Nos. 674—679

No. 676.	Needle, 1 inch long...	3/0	No. 678.	Needle, 3 inches long...	4/0
No. 677.	,, 2 inches long	3/6	No. 679.	,, 4 ,, ,, ...	4/6

No. 680.

No. 695.

No. 680.	Electrode, holding 12 steel needles	8/0
No. 682.	Electrode, holding 12 platinum needles	16/0
No. 695.	Voltolini's double needles	3/3
No. 710.	Bougie electrode, with Brodie's handle, for the treatment of strictures of the urethra	8/6
No. 712.	The same with 12 slides, of various sizes	18/0

No. 715.

No. 715.	Complete set of 12 urethral electrodes, in case ...	£3 0 0
No. 730.	Electrode for electrolysis of the Eustachian tube ...	0 12 6

No. 735. Electrode for electrolysis of the lachrymal duct, with blunt platinum top 10/6

No. 735.

No. 738. Electrode for electrolysis of the cervix uteri 6/0

No 740. Bougie electrode, with 12 heads of various sizes, for the treatment of strictures of the rectum 18/6

ELECTRODES FOR THE TREATMENT OF UTERINE FIBROIDS.

No. 745.

No. 745. Dr. Apostoli's carbon electrodes £0 8 0

No. 748

No. 748. Dr. Apostoli's platinum sound, with handle and 3 insulators of different lengths 5 0 0

No. 749. Dr. Apostoli's sound, consisting of a copper wire 2·7 m.m. thick, over this is drawn a tube of pure platinum—the walls of this tube are 0·3 m.m. thick—the ends of the tube are also of pure platinum. Price, including handle and insulator 2 17 0

We guarantee that this sound will wear exactly as well as No. 748.

No. 750. Steel trocars ... ... each 2/6

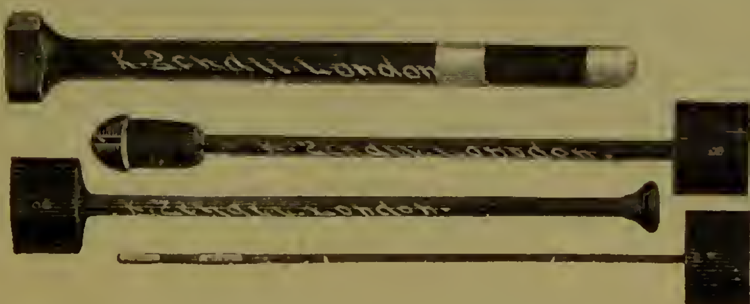
No. 780. Dr. Milne Murray's electrode for uterine fibroids ... £2 15 0

No. 789.

No. 787.

No. 785.

No. 790.



No. 785. Dr. Apostoli's double concentric disc electrode 12/6
No. 787. Ditto ditto ditto 13/6
No. 789. Dr. Apostoli's double vaginal electrode 12/6
No. 790. ,, ,, electrode for the urethra and uterus ... 10/6

(The electrodes Nos. 785 to 790 are intended for the localization of galvanic and faradic currents.)

No. 795. Tin Plate, with connecting cord, to be used with potter's clay 6/0

(See also Electrodes Nos. 514 and 525.)

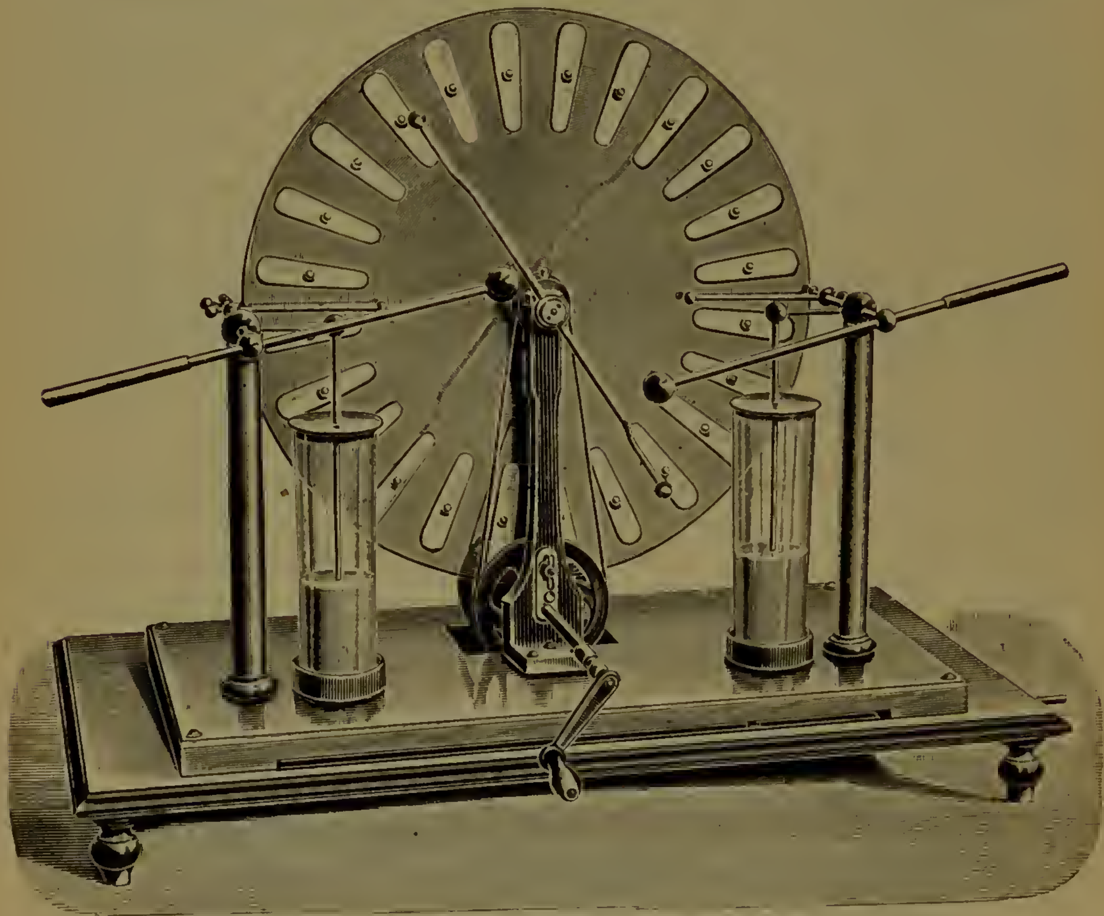
APPARATUS FOR FRANKLINISATION.

(Static Electricity. See also pages 43—44.)

Of all the various constructions of statical machines the Wimshurst machines have been found to be the most reliable ones.

WIMSHURST MACHINES.

No. 850.	Two plates, diameter 16 inches	£7 15 0	
No. 851.	,, ,, 20½ ,, ...	9 0 0	
No. 852.	,, ,, 24½ ,, ...	11 0 0	

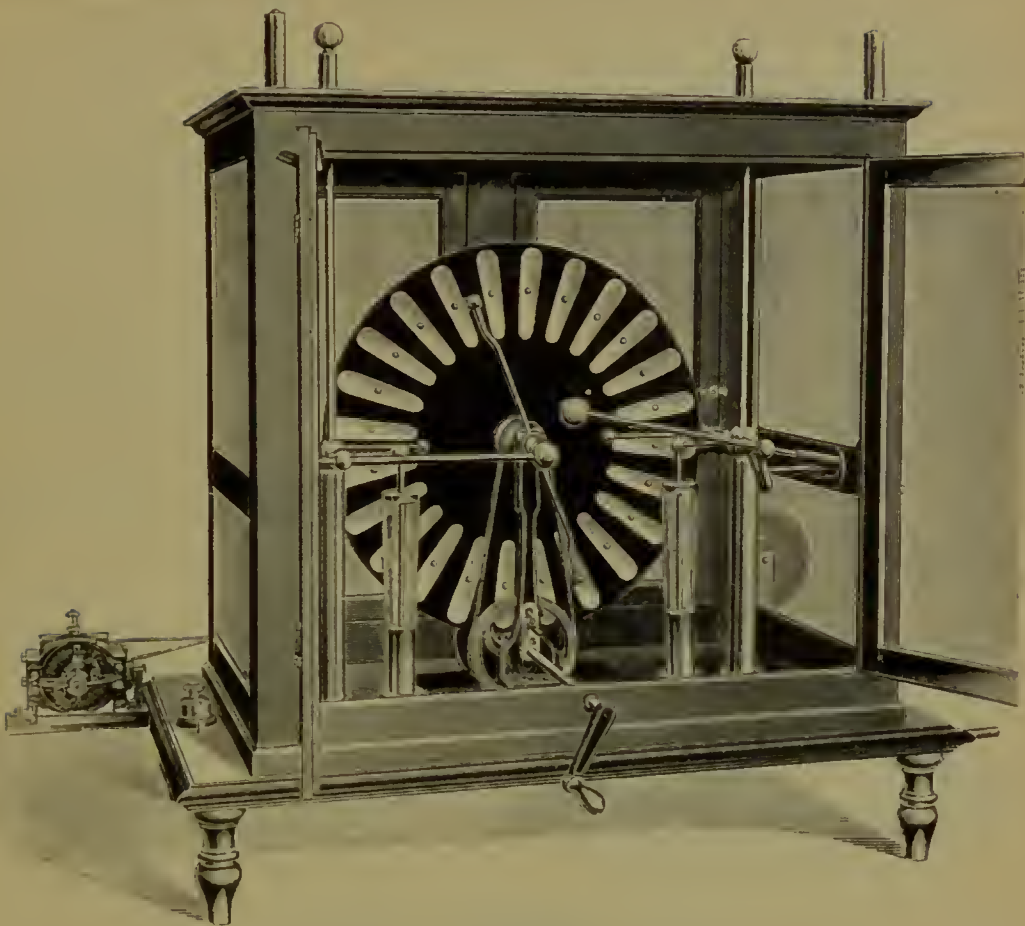


No. 861.

Machines of best quality and finish.

No. 861.	Two plates, diameter 20½ inches, Fig. 861	£12 0 0
No. 862.	,, ,, 24½ ,, ...	14 10 0
No. 865.	Large Wimshurst machine with four plates of 24½ inch diameter, best quality, in polished glass case, with space and transmission for electric motor, and arrangement for regulating the spark length (see illustration, No. 865)	31 0 0

Larger machines, with six to twelve plates, of 24 to 36 inches diameter, are made to order. Prices and photographs can be had on application.



No. 865.

No. 870. Electrode, with wooden ball or wooden point £0 8 6

No. 871. ,, ,, metal ball or metal point 0 8 6

No. 875. Large insulating platform, to put a chair on it 2 0 0

No. 879. Multiple point electrode, Fig. 879 £1 12 0

No. 880. Bowl for the head 1 10 0

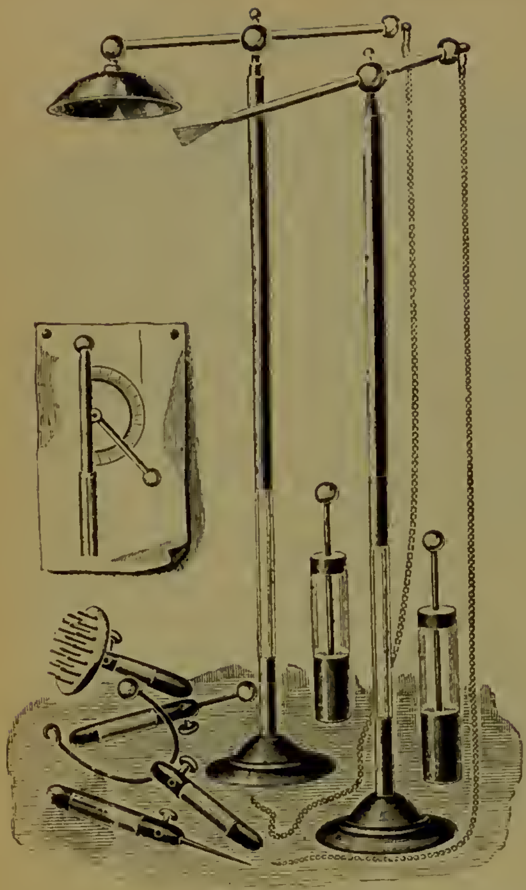
No. 882. Ozone apparatus 1 6 0

No. 885. Insulated cable, with balls at the ends ... ... per yard 0 2 6

No. 889. Glass tube, with two movable balls for regulating the length of the sparks £0 15 0

No. 889.

No. 879



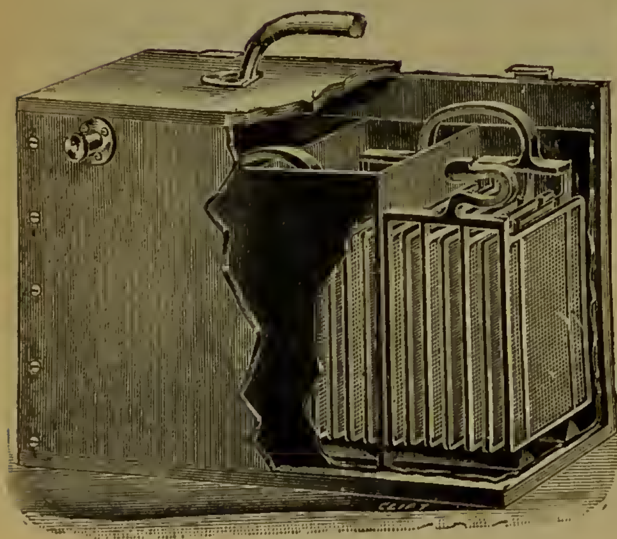
No. 896. Leyden jars according to size ... 6/- to £1 1 0

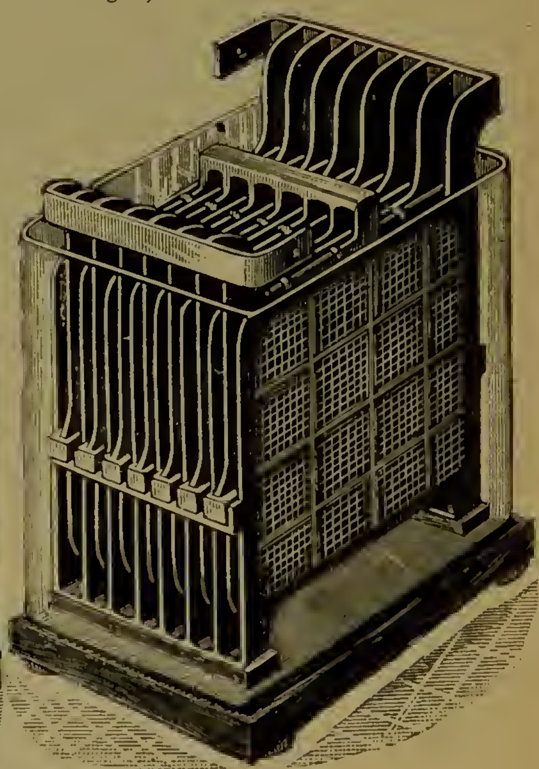
Glass cases for the static machines ... ... £3 to £15.

For Electro Motors for driving static machines, see Nos. 1351—1365.

ACCUMULATORS.

(See also pages 28—31.)





	No.	Capacity in ampère hours.	Charge or discharge.	Weight.	Price charged.
Single cells in lead-lined Teak Cases, etc.	907	14	3 ampères	9 lbs.	£0 12 6
	908	21	5 ,,	11 ,,	0 14 0
	910	35	8 ,,	17 ,,	0 17 0
	911	50	15 ,,	22 ,,	1 0 0
	912	70	20 ,,	30 ,,	1 6 0

No. 916. 8-Volt accumulator, for surgical lamps or small motors, capacity 21 ampère hours, **with rheostat** ... £3 12 0

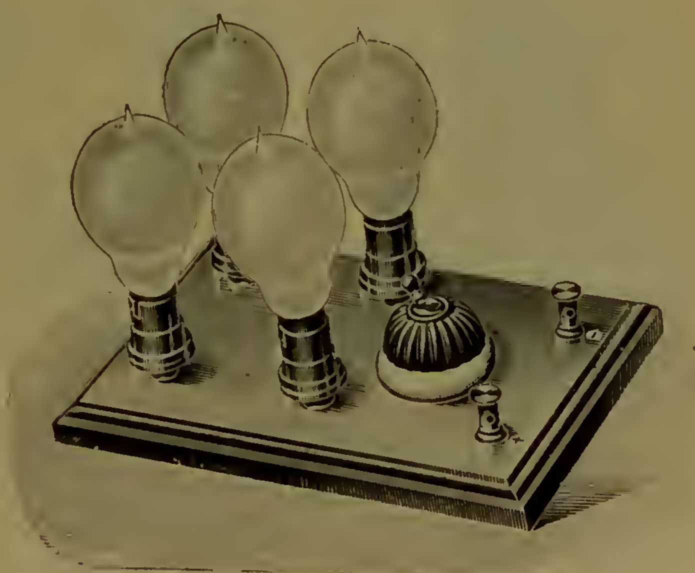
No. 931. 4-Volt accumulator, for cautery only, capacity 50 ampère hours, **with rheostat** 3 5 0

No. 932. 8-Volt accumulator, for cautery, surgical motors, and surgical lamps, capacity 50 ampère hours, **with rheostat** 5 15 0

No. 933. 12-Volt accumulator, for working spark coils, cautery burners, surgical motors or surgical lamps, capacity 50 ampère hours, **with rheostat** ... 7 10 0

RESISTANCES FOR CHARGING ACCUMULATORS FROM THE MAINS.

No. 950.



No. 952.

No. 950.	Resistance lamp holder, with terminals for connection with accumulators, Fig. 950	£0	9	0

This Lamp Holder is inserted into an ordinary Edison lamp holder, and is suitable for lamps up to 60-candle power (2 ampères) on a 100 volt supply, or 1 ampère on a 200 volt supply. The poles are ascertained by means of pole-finding paper.

No. 952.	Board with 4 lamp holders, switch, fuse and terminals to connect with accumulators, Fig. 952	1	12	0

This board is suitable for currents up to 8 ampères on a 100 volt supply, or 4 ampères on a 200 volt supply.

No. 954.	Similar board, with 8 lamp holders	2	14	0

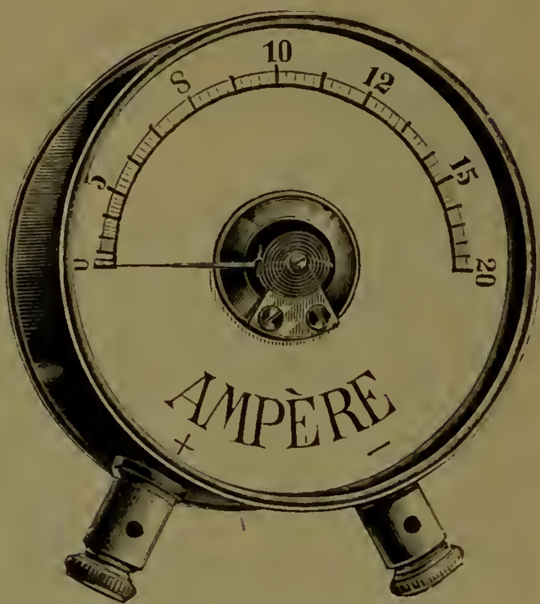
Suitable up to 16 ampères with 100 volts, or 8 ampères with 200 volts.

No. 958.	Book with pole-finding paper	0	1	6

The negative pole makes a red stain on the moist paper.

AMPÈRE METERS, VOLTMETERS, RHEOSTATS.

No. 961.



No. 966.

No. 961.	Ampère meter, Fig. 961, showing from 0·1 to 2·0 ampères	£1	10	0
No. 963.	Ampère meter, Fig. 961, showing from 2 to 25 ampères...	1	3	0
No. 966.	Ampère meter, Fig. 966, showing from 0·1 to 10 ampères	1	16	0

No. 967. Ampère meter, Fig. 966, showing from 1 ampère to 20 ampères £1 16 0

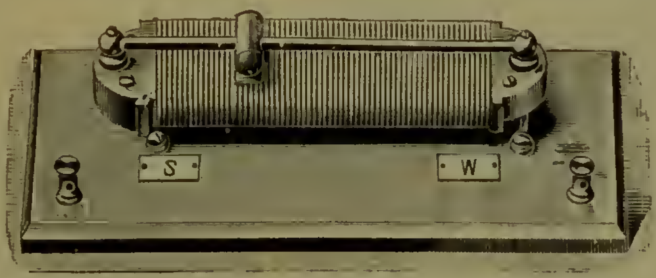
For milliampère meters, see pages 85—87.

No. 972. Voltmeter, showing from 0·1 volt to 5 volts every $\frac{1}{10}$th volt, for testing accumulators, etc. 1 6 0

No. 973. Voltmeter, showing from 1 volt to 20 volts every single volt (similar to Fig. 966)... ... ... 1 16 0

No. 975. Voltmeter showing from 1 volt to 75 volts or 100 volts ... 2 0 0

Ampèremeters and Voltmeters with other divisions than those quoted above can be made to order.



No. 980.

No. 980. Rheostat wound on slate core, and mounted on polished mahogany board with two terminals, Fig. 980, resistance 30 ohms, suitable for surgical lamps requiring not more than 2·0 ampères £1 0 0

No. 981. Similar Rheostat, resistance 10 ohms, suitable for lamps and motors requiring not more than 5 ampères ... 1 0 0

No. 983. Similar Rheostat, resistance about 0·8 ohm, suitable for cautery burners and spark coils, requiring not more than 16 ampères 1 5 0

No. 985. Similar Rheostat, but of double the length, total resistance about 1·0 ohm, suitable for cautery burners and spark coils requiring up to 30 ampères 2 10 0

Other sizes, or a combination of several of these rheostats on a board with switch, fuse, terminals, Ampèremeter, Voltmeter, etc., can be made to order.

For rheostats with *high* resistances, for galvanisation, etc., see pages 87, 88.

For rheostats for utilizing the current from the main for galvanisation, cautery, surgical lamps, spark coils, etc., see pages 131—141.

BICHROMATE BATTERIES FOR GALVANIC CAUTERY & FOR WORKING SPARK COILS.

(See also pages 23—28.)

*The batteries marked * may also be used for lighting surgical lamps and driving surgical motors.*

The batteries marked † may also be used for working spark coils.

Batteries with two cells suffice for eye operations with galvanic cautery: for all other operations where galvanic cautery may be applied, four cells are required. Batteries with six or more cells are supplied, partly to enable the operator to double the constancy of his cells by connecting them up parallel, and partly for making the batteries useful for surgical lamps and for exciting spark coils.

SIMPLE BATTERIES,

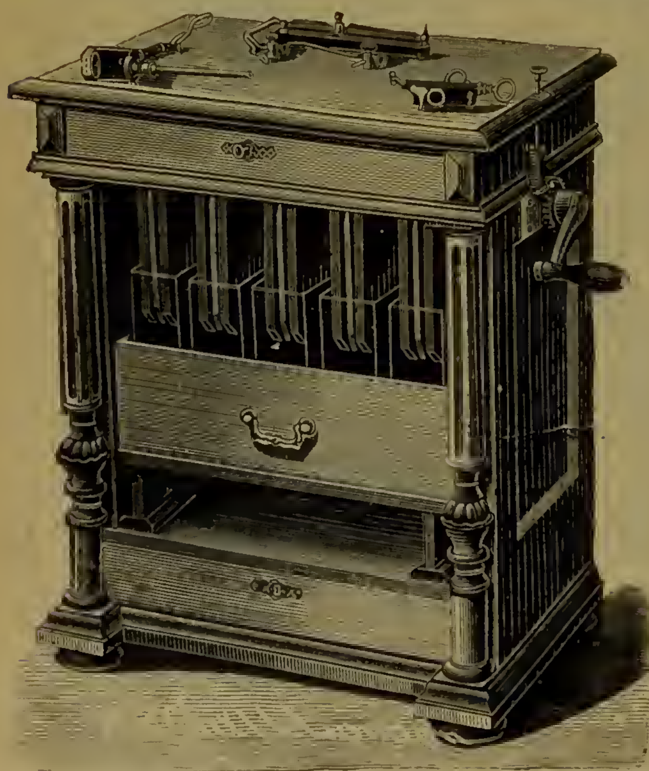
IN OAK CASE, FOR HOSPITALS, &c.

Each cell gives a current of over 30 ampères.

No. 1000.	2 cells	.	£3	0	0
*No. 1001.	4 ,,	.	4	0	0
†*No. 1003.	8 ,,	.	6	10	0
†*No. 1004.	12 ,,	.	8	10	0

The prices include connecting cords. Rheostat for any of the above batteries, extra 18/-

No. 1001.



No. 1010.

LARGE BATTERIES,

FOR SPECIALISTS OF THROAT, NOSE, ETC., DISEASES, AND HOSPITALS.

IN OAK CASE, with Rheostat and Cords.

†*No. 1009.	10 cells	£18	10	0
†*No. 1010.	12 ,,	21	0	0

Spare zincs for batteries Nos. 1000—1010, consisting of 11 parts pure zinc, and 1 part of mercury, weight 2 lbs. 4 oz. . 2/6 each.

One pair of spare carbons, 6/0 each.

Spare glasses 1/9 ,,

SCHALL'S PORTABLE CAUTERY BATTERY,

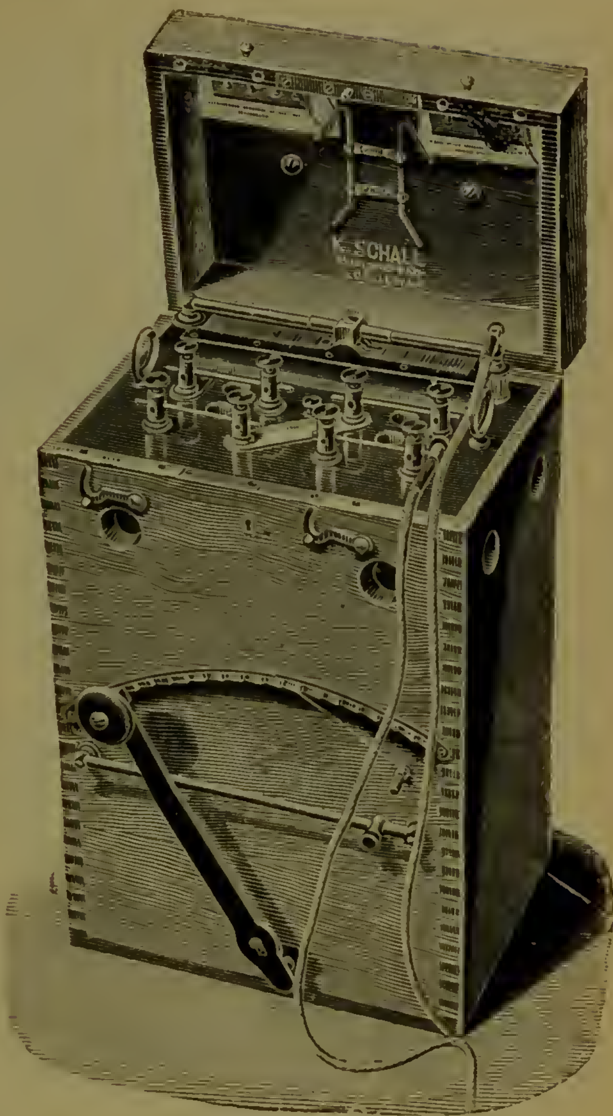
In Oak Case, with rheostat and cords.

No. 1040. 4 cells, $7 \times 9\frac{1}{2} \times 15$ inches. Weight, 24 lbs.,
Fig. 1040 ... ... **£5 10 0**

*No. 1042. 6 cells ... **7 15 0**

Of the many *unsolicited* testimonials we have received about this battery, we will mention here one only. Mr. Walter Whitehead, of Manchester, writes :—"*Four years ago I obtained a battery from you* (*No.* 1042) *which I have used ever since with complete satisfaction.*"

The 6-cell battery is provided with a current collector in addition to the above-mentioned accessories.



No. 1040.

There are now about 800 batteries No. 1040 and No. 1042 in use in Great Britain and the Colonies, the best proof of their practical construction and reliable working.† These

† We have supplied them, amongst many others, to the following hospitals and medical men :—

St. Bartholomew's, Charing Cross, Guy's, St. Peter's, St. Thomas's, Westminster, Great Northern, London, St. Mary's, and Westminster Hospitals ; Lock Hospital, Soho Square ; Hospital for Diseases of the Heart and Paralysis, German Hospital, Victoria Hospital for Children, Central London Ophthalmic and Queen's Jubilee Hospitals, Royal Hospital for Diseases of the Chest, etc.

Royal Infirmaries, Bristol, Glasgow, Windsor, Edinburgh ; Western Infirmary, Glasgow ; Queen's Hospital, Birmingham ; Bristol Eye Hospital ; Kent County Ophthalmic Hospital, Maidstone ; Infirmary, Wolverhampton ; Eye and Ear Hospital, Liverpool ; Eye and Ear Infirmaries, Southampton and Bath ; Ear and Throat Hospital, Birmingham ; General Infirmaries, Leeds and Sheffield ; Children's Hospital, Pendlebury ; Ear Institution, Manchester ; Throat and Ear Hospital, Nottingham ; Eye Hospital, Shrewsbury ; South Devon Hospital, Plymouth ; Children's Hospital, Sheffield ; Eye Hospital, Oxford ; Hospital for Sick Children, Newcastle ; Grimsby and District Hospital ; Sanatorium, Weymouth ;

batteries can be used equally well for cautery and for light, and they may be used to a limited extent for electrolysis, for removing hairs, destroying nævi, &c., as long as not more than about 10 milliampères are required, or when both poles (needles) are introduced through the skin.

The acid for the batteries Nos. 1040 and 1042 is contained in strong ebonite vessels, pressed out of one piece. The ebonite cell can be moved up and down by means of a handle on the outside of the battery, and can be fixed at any elevation. A 4-cell battery keeps a platinum burner incandescent for about thirty minutes, and requires for its filling half a gallon of acid solution. If the battery is used several times every day, refilling is necessary about every four weeks, but if it is used only now and then, refilling is necessary every three months. There is little danger of any acid being spilled in carrying the batteries, as perforated plates float on the acid and prevent its splashing over. In plunging the battery in, the perforated plate is pressed down to the bottom of the ebonite vessel, and rises again to the surface as soon as the elements are removed from the acid.

Spare zincs for batteries Nos. 1040 and 1042, consisting of 10 parts of zinc and 1 part of mercury, weight 1 lb. 12 ozs.	... each	2/6
One pair of carbons	... ..	6/0
Ebonite vessel for 4-cell battery	... ..	15/6
Ditto do 6-cell do	... .,	21/0
Acid, ready mixed for charging the batteries Nos. 1000 to 1042	per gall.	3/0

Accumulators for cautery and spark coils will be found on page 90. Rheostats and Transformers for utilizing the currents from Dynamos for cautery and spark coils will be found on pages 135-139.

Wolverhampton and Staffordshire Infirmary; Manchester and Salford Hospital; Royal Sussex County Hospital, Guildford; Ripon Hospital, Simla; Medical College, Lahore, etc.

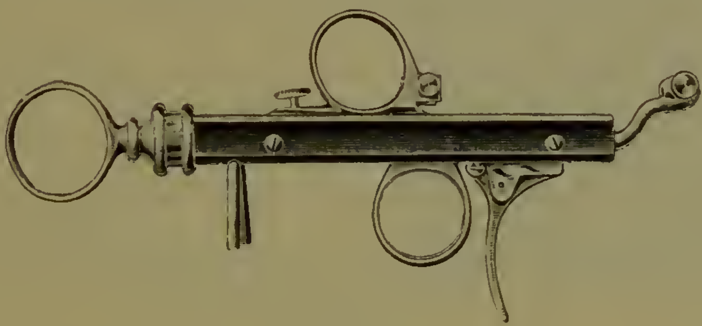
A. Anderson, G. W. Anderson, A. W. Addinsell, H. T. Butlin, Buckstone Brown, S. Beauchamp, W. Bull, G. A. Critchett, Bruce Clarke, T. H. Clarke, R. Clarke, C. Cripps, A. W. Clemow, G. Caley, E. Curwen, M. Collier, Stretch Dowse, E. H. Ezard, S. Edwards, H. Fenwick, E. A. Fletcher, J. E. Foster, W. Fearnley, Gage-Brown, W. S. A. Griffith, H. T. Griffiths, W. Groome, S. Grubb, F. de Havilland Hall, Reginald Harrison, H. Hetley, W. S. Hedley, Victor Horsley, T. Hutchinson, W. R. Holmes, L. Hudson, T. S. Harvey, G. Herschell, Lewis Jones, C. James, H. J. Johnson, W. H. Kelson, T. E. Lane, H. Lack, Malcolm Morris, H. W. Mackenzie, T. Macgregor, R. Owen, F. B. O'Connor, H. Oppenheimer, S. Paget. B. Pollard, L. H. Pegler, C. A. Parker, T. H. Prangley, Pepperdene, John J. Pollard, Prof. W. Rose, R. Rushworth, A. Routh, T. B. Ryley, F. A. Richardson, D. Roberts, C. Symmonds, R. J. A. Swan, G. Stoker, A. M. Shield, T. B. Smith, W. R. Stewart, Dr. Shearer, Dr. Stokes, Sir Henry Thompson, M. Tuchmann, G. L. Thomson, H. A. des Voeux, O. Ward, E. B. Waggett, G. L. Wilkin, P. Whitcombe, C. Williams, R. H. Wilbe, H. F. Waterhouse, etc.

Drs. W. Browne, Nelson, Sinclair, O'Neill, Belfast; Brooke, Ransome, Walter Whitehead, Manchester; Reith, Garden, Macgregor, Riddell, Will, Aberdeen; Johnston, Murdock, Duncanson, McBride, Edinburgh; Macintyre, Nicol, Newman, Napier, Renton, White, Glasgow; Freeman, Ferry, Flemming, Bath; Wilson, Ranking, Neild, Crapper, Tunbridge Wells; Winders, Price, Abram, Rudge, Reading; Williams, Dunbar, Baron, Clifton; Prichard, Thomas, Cardiff; Cuff, Godfrey, Thompson, Scarborough; Taylor, Pryce, Nottingham; Bramwell, Ward-Humphrey, Cheltenham; Alexander, Southsea; Dukes, Rugby; Collins, Wanstead; Smith, Northwich; Hardy, Huddersfield; Hewland, St. Leonards;

INSTRUMENTS FOR GALVANIC CAUTERY.

The "Universal" Handles can be used for burners *and* snares.

The "Simple" Handles can be used for the burners *only*.



No. 1100.

No. 1100. Universal Handle, by Dr. Schech, Fig. 1100 ... ... £1 7 0

No. 1101.

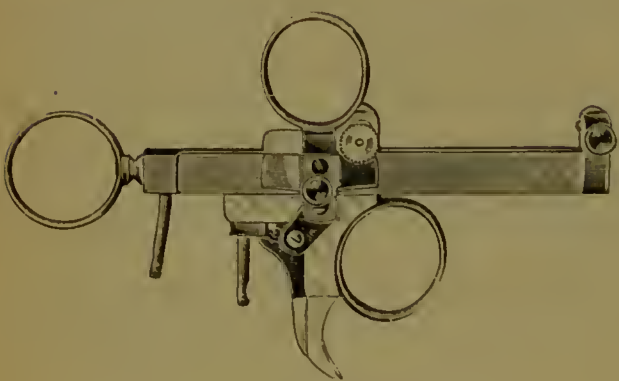
No. 1101. Simple Handle, by Dr. Schech, Fig. 1101 ... ... £0 15 0

Stamp, Plympton: Friel, Waterford; Cowper, Shanklin; Stamberg, Jersey; Marsh, Myers-Ward, Wilders, Birmingham; Davies, Bridgend; Hartigan, East Grinstead; Holderness, Windsor; Cant, Sympson, Lincoln; Newman, Stamford; Curry, Taylor, Liverpool; Heard, Monkstown; Tebb, Bournemouth; Gillibrand, Bolton; Stewart, Denton; Coleman, Hemsworth; Kingscote, Salisbury; Thorne, East Retford; Charnley, Shrewsbury; Barnes, Erith; Lowther, Grange-over-Sands; Morgan, Seaford; Atkins, Pearson, Cork; Gwillim, Southampton; MacEvan, Dundee; Walker, Leeds; Balfour, Presteign; Ferguson, Malvern; Chapman, Hereford; Ruttle, Accrington; Dobie, Chester; Eccles, Plymouth; Knight, Griffith, Swansea; Stewart, Nottingham; Thomson, Newbury; Fogerty, Limerick; Craig, Londonderry; Thomson, Luton; Shipman, Grantham; Jones, Aberdare; Macaulay, Halifax; Lord, Colwyn Bay; Martin, Weston-super-Mare; Bennet, South Shields; E. S. Ford, Galloway; Gamlin, Hartlepool; Fearnley, Harrogate; Brookes, Felixstowe; Thompson, Bideford; Tyson, Folkestone; E. Thompson, Omagh; Bowes, Herne Bay; Coulter, Garry, Calcutta; Duke, MacDougall, Cannes; Dr. Rendall, Mentone; St. Clair Thomson, Florence; Wilmot, Llewellyn, Melbourne; Muskett, Farrant, Wilkinson, Clinton, Brady, Williams, McCormick, Hall, Sydney; Sutcliffe, Indianopolis; Silver, Milbury, New York; Taylor, Canada; Scholtz, Stevenson, Fuller, Rubidge, Cape Town; Considine, Port Elizabeth; Duston, Quick, Bombay; Henderson, Jamaica; Cantlie, Hongkong; Frend, Rosario; Baker, Rangoon; Rendell, St. John's; Thompson, Hankow; Mack Kenn, Buenos Ayres; Lotz, Freemantle; Daws, Stuart, Johannesburg; Holland, St. Moritz; Lemander, Upsala; Faulkner, Foowoombo; Lentas, Darjeeling, etc., etc.

No. 1104.

No. 1103. Schech's Handles are mostly used. The price of a case containing Universal Handle, six different burners, two ligature tubes and one porcelain burner, platinum wire for one loop, and steel wire for twelve loops is £3 0 0

No. 1104. Schech's Universal Handle and Simple Handle, with ten platinum burners, two ligature tubes, two porcelain burners, platinum and steel wire, in case, Fig. 1104 ... £4 4 0

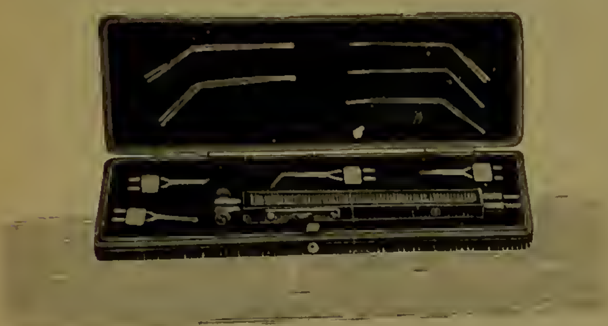


No. 1112.

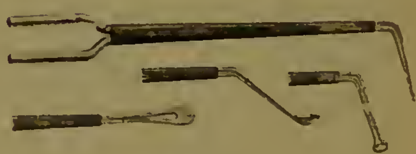
No. 1112.

Universal Handle, by Dr. Kuttner.

Fig. 1112 ... £1 14 0



No. 1116.

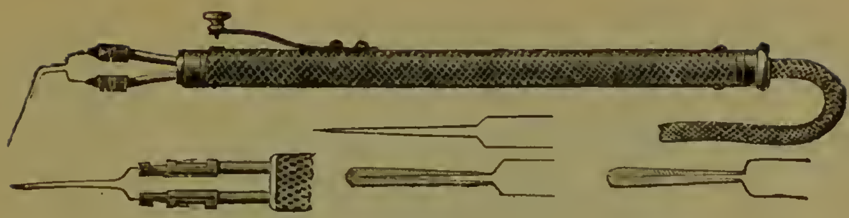


No. 1117.

No. 1116.	Handle for eye operations, with five burners, in case, by Prof. Sattler-Nieden, Fig. 1116	£1 5 0
No. 1117.	The same instrument, with five additional burners for the ear, Fig. 1117	1 15 0

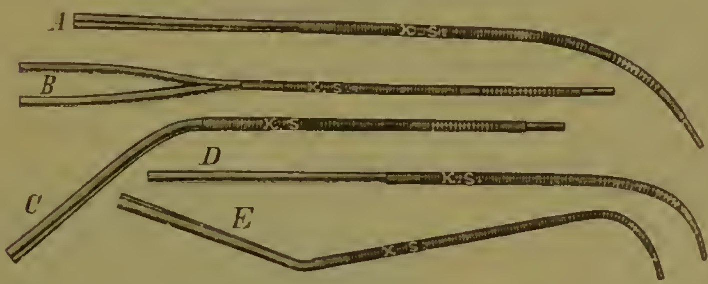
No. 1118.

No. 1118.	Handle for small burners, Fig. 1118	0 15 0



No. 1119.

No. 1119. Handle for dental, etc., purposes, with five burners, in case, Fig. 1119 ... ... £1 10 0

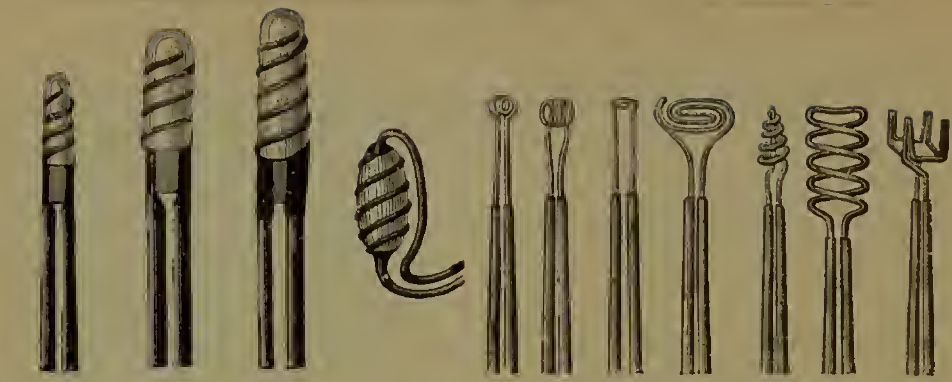


Shape and description of the ordinary curves of burners and ligature tubes. The length is 4, 6, or 8 inches, as desired. Other curves or burners can be made to order.

In ordering, please state the desired length in inches, and for the curve quote the capital letter printed by the side, and the form of the platinum, with its accompanying figure as shown in Nos. 1120 to 1161.

Nos. 1120 1121 1122 1123 1125 1126 1127 1128 1129 1130

Nos. 1131 1132 1133 1133a 1134 1135 1136 1137 1140 1141 1142



Nos. 1150 1151 1152 1153 1155 1156 1157 1158 1159 1160 1161

Shape and numbers of the burners: Nos. 1120—1142 platinum, 1150—1153 porcelain, 1155—1169 platinum.

Prices:—Burners Nos. 1120—1137, 3/-; 1140—1152, 4/9; 1155—1169, 5/3; ligature tubes, 3/-.

If desired, an alloy of platinum and iridium can be used for the burners instead of pure platinum. The alloy remains stiff and hard, whereas pure platinum gets soft after it has been incandescent.

Nos. 1120, 1122, 1123, 1125, 1133 and 1150, are the most frequently used shapes of burners, and if not otherwise ordered, these shapes only—some straight for nose, &c., and some bent for the larynx—will be used for the sets Nos. 1103 and 1104.

		£	s.	d.
	Platinum wire for one large loop	£0	2	6
	Steel wire, 0·3 or 0·4 millimètre thick, for six loops	0	1	0
	Cases for cautery instruments	0	4	0
No. 1175.	Prof. Bottini's instrument for burning the prostate ... (As supplied to Mr. Bruce Clarke, Mr. Fenwick, and others.)	3	10	0
No. 1178.	Water cooling apparatus for instrument No. 1175, with bellows, &c., complete	1	10	0

BATTERIES FOR ELECTRIC LIGHT.

(See also pages 31—35.)

For the following batteries we have stated approximately how many ampère hours the elements used in the batteries will yield, and for the instruments we have stated the average number of ampères required by the lamps. These two figures will help to find out how many hours a battery will keep a lamp incandescent before having to be re-charged. For instance, a battery fitted with cells of 10 ampère hours capacity will keep a lamp requiring 0·5 ampère incandescent for 20 hours; a lamp requiring 1 ampère for 10 hours; a lamp requiring 1·5 ampere for 6·5 hours altogether; in other words, if a lamp requiring 0·5 ampère is kept incandescent for *5 minutes daily*, and the cells of the battery have a capacity of 10 ampère hours, the battery will be exhausted, and want re-charging after about 8 months.

A 6-cell battery can light lamps requiring 5—8, an 8-cell battery can light lamps requiring 5—11 volts.

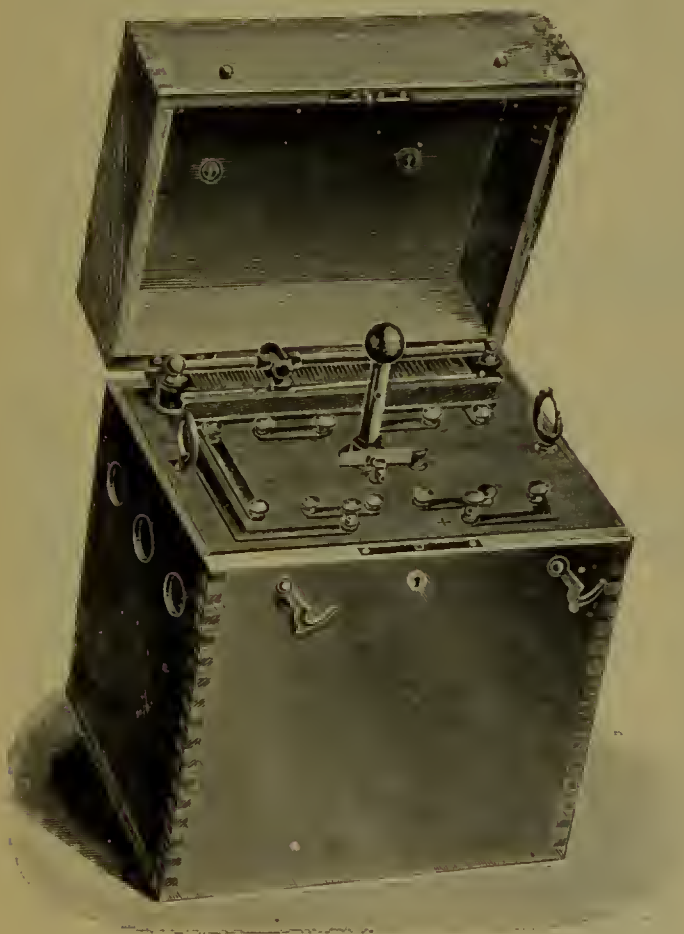
Leclanché Dry Batteries for electric light, with rheostat and cords.

(See also page 33.)

			Capacity in amp. hours.	Weight.	£	s.	d.
No. 1186.	8 cells,	6 × 9½ × 8 inches	15	15 lbs.	£2	7	0
,, 1188.	8 ,,	6½ × 13 × 9 ,,	30	24 ,,	2	14	0

No. 1186.

New cells for the batteries No. 1186	each	£0	2	6
,, ,, ,, 1188	,,	0	3	0



No. 1192.

No. 1192. 6 cell Bichromate Battery, with rheostat, for surgical lamps £3 15 0

This battery gives a *perfectly steady* light for 3 to 4 hours, and can be used for all lamps requiring between 4 and 11 volts and 0·4 to 1·5 ampères. Indiarubber floats prevent the spilling of the acid, and the battery can easily be recharged and kept in order for many years without the help of an electrician. It is specially useful for Surgeons using incandescent lamps at irregular intervals, and for Surgeons living abroad.

For Accumulators for surgical lamps, see Nos. 916-935.

For Bichromate Batteries for surgical lamps, see also Nos. 1001-1042.

For Rheostats and transformers for utilizing the current from the main for small surgical lamps, see Nos. 1642-1696.

INSTRUMENTS FOR ELECTRIC LIGHT.

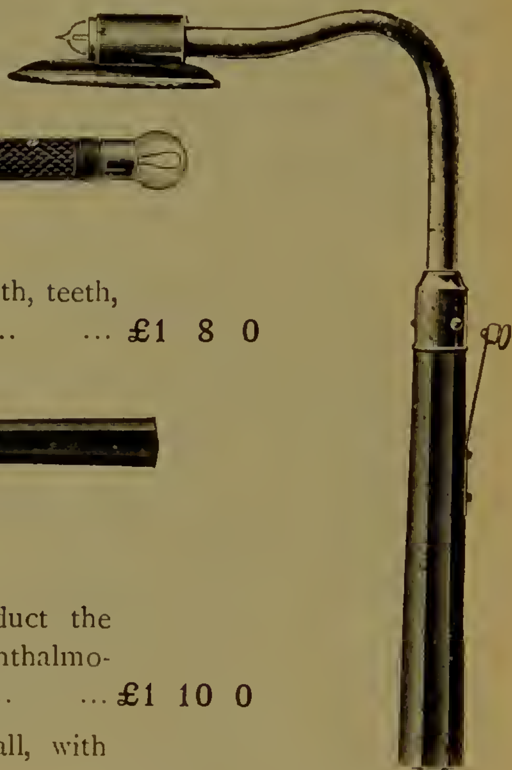
Mounted spare lamps for the Instruments Nos. 1200—1350 *cost* 2/- *each.*

No. 1200.

No. 1200. **Laryngoscope,** by Dr. Semon, with case and one spare lamp £1 14 0

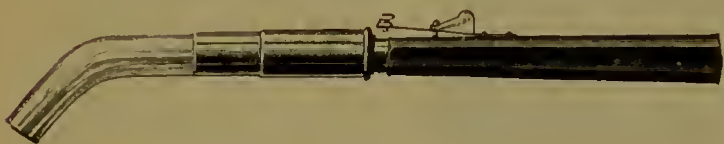
The lamps require 7 to 11 volts and 1 ampère.

This instrument can also be very advantageously used in dental operations. Further, the mirror can be removed, and the lamp, which has a very thin handle, can be used for the illumination of other cavities of the body.



No. 1202.

No. 1202. Lamp for examining the mouth, teeth, etc., as shown in Fig. 1202 ... ... £1 8 0



No. 1204.

No. 1204. Lamp with glass rod to conduct the light without any heat, for ophthalmoscopic purposes £1 10 0

No. 1205. **Tongue-depressor,** by Schall, with case and one spare lamp £1 15 0

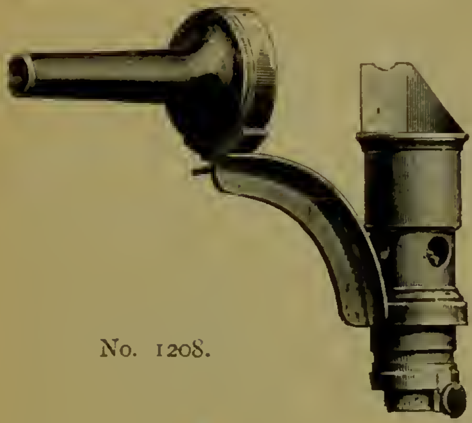
No. 1205.

The lamps require 7 to 8 volts and 1·3 ampère.

The ebonite spatula can be removed to be cleaned.

No. 1206. Similar instrument, but with larger lamps, for making the antrum transparent; the lamps give a light of about 4 candles £2 0 0

The lamps require 11 volts and 1·6 ampère.



No. 1208.

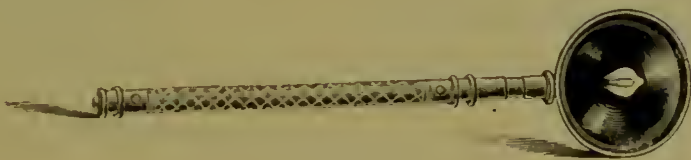
No. 1208. Schall's **Otoscope,** fitted with incandescent lamp, case, spare lamp, and three ear funnels in case ... **£2 15 0**
(Patent No. 1725, 1896.)

This instrument gives a very brilliant light, and allows perfectly free movement for the operating instruments.

No. 1210. **Incandescent lamp,** for vaginal speculum, with one spare lamp ... **£1 5 0**

No. 1210.

The lamp is carried on a spring, which can be clamped to any speculum. The lamps require 7 volts and 1 ampère.



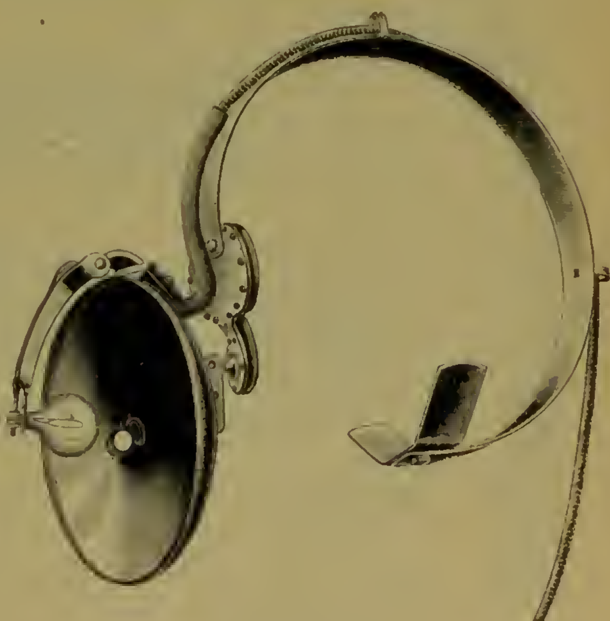
No. 1211.

No. 1211. **Hand-lamp with platinized reflector,** for abdominal and other operations, in case, with one spare lamp **£1 15 0**
The lamps require 8 to 10 volts and 0·75 ampère.

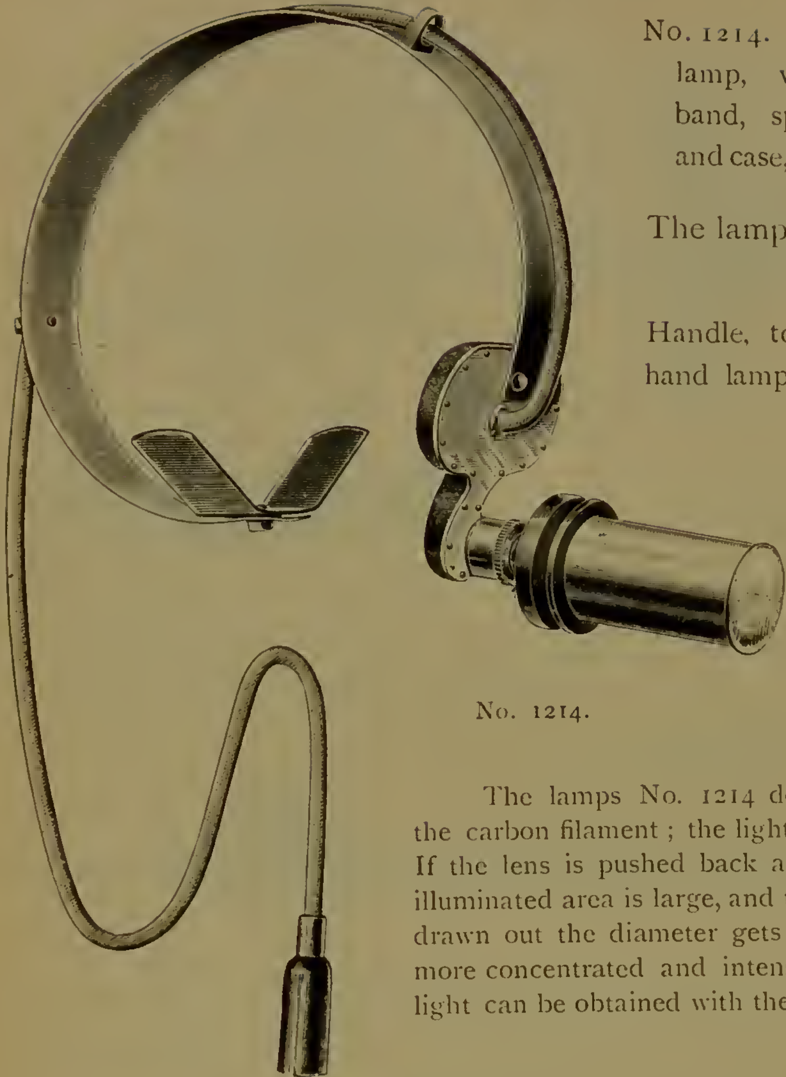
No. 1212. Forehead lamp, with concave mirror and lamp, as shown in Fig. 1212, with case and spare lamp **£2 6 0**

This lamp gives an exellent light.

The lamps require 8 volts and 1 ampère.



No. 1212.



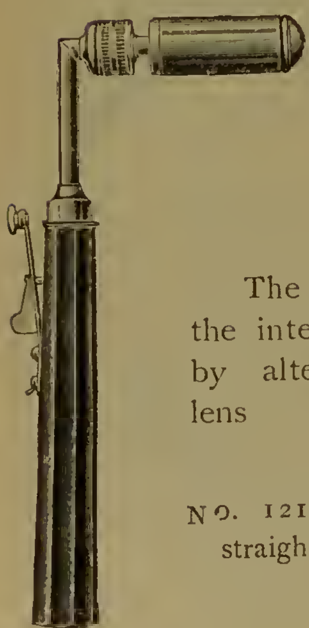
No. 1214. Forehead lamp, with steel band, spare lamp and case, Fig. 1214 £1 18 0

The lamps require 8 volts and 1·0 ampère.

Handle, to use No. 1216 as a hand lamp (similar to No. 1215), 16/0.

No. 1214.

The lamps No. 1214 do not show a picture of the carbon filament; the light is bright and homogen. If the lens is pushed back as far as it will go, the illuminated area is large, and the light diffused; if it is drawn out the diameter gets smaller, but the light is more concentrated and intense. A parallel beam of light can be obtained with the lamp if desired.

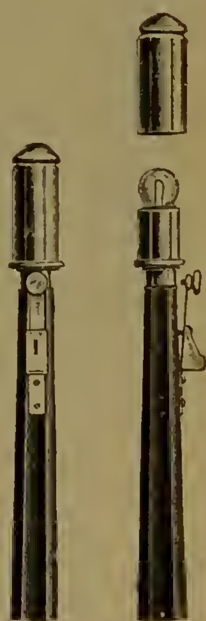


No. 1215. Hand Lamp, with bull's eye, for surgical operations, with case and spare lamp £2 0 0

The diameter of the illuminated area and the intensity of the light, can be regulated by altering the distance of lamp and lens

No. 1216. The same instrument, straight £1 16 0

No. 1215.



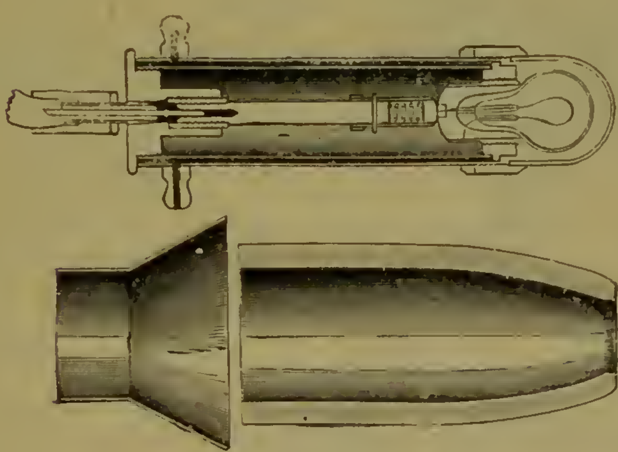
No. 1216.

No. 1218. Lamp with bull's eye, and stand with universal movement, for surgical and dental operations, microscopic work, etc. Fig. 1218 ... ... £2 10 0

No. 1218.

No. 1219.

No. 1219. Lamp on stand, as shown in Fig. 1219. The optical arrangement consists of three lenses, the position of which can be varied so that either diffused light or a parallel beam of light is obtained. The lamp gives a powerful light and is very convenient for dermatological, microscopic, etc., purposes £3 0 0

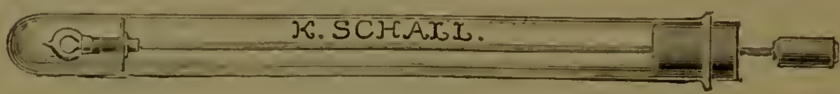


No. 1220.

No. 1220. Lamp for transillumination of larynx, nose, temples, ear, etc, with indiarubber funnel and water cooling arrangement £1 18 0

No. 1250. **Phantom,** with imitation of mouth, larynx, post-nasal cavity and ear, with 30 coloured pictures of the principal diseases of the larynx by Dr. Schech, 8 coloured pictures of the post-nasal cavity, and 24 coloured pictures of the ear ... **£1 1 0**

No. 1255. **Lamp for abdominal operations,** made for St. Bartholomew's Hospital, price, including one spare lamp and case, Fig. 1255 ... ... **£1 12 0**



No. 1255.

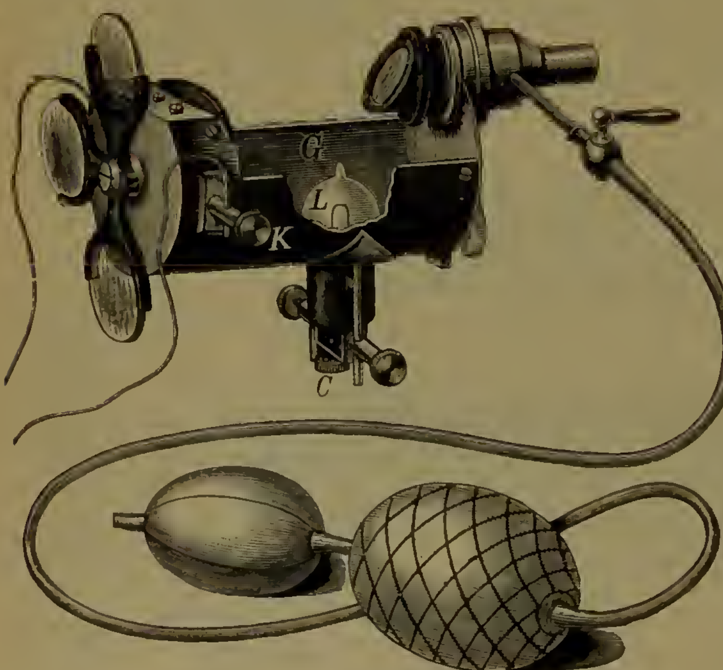
The lamps require 9 volts and 0·75 ampère.

It is introduced through wounds during abdominal operations, to find bleeding arteries, etc. The lamp is protected so as not to dazzle the eye of the operator. The instrument can easily be sterilized.

No. 1256. **Fenwick's Urethroscope,** with one spare lamp, inflating arrangement and double bellows **£4 0 0**

The lamps require 9 volts and 0·75 ampère.

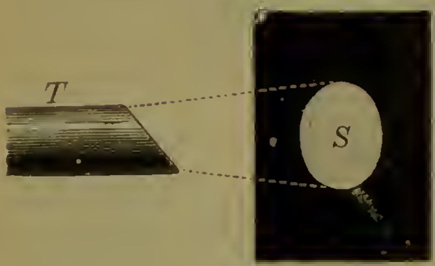
This instrument can be used equally well for the rectum, ear, œsophagus, nose, vagina, etc.



No. 1256.

In the mode of reflection, this instrument is a distinct innovation. In other endoscopic instruments the lamp was usually placed in front of a perforated mirror, and the operator looked at the object through a perforation; but in this instrument a mirror is placed behind the lamp, and its concavity permits of the concentration of the rays of the light coming from the lamp upon the object, the operator looking over the upper edge of the mirror into the tube fixed to the instrument. In this way he is enabled, even in the case of such narrow and long canals as the male urethra, to observe and to use the operating instruments at the same time. This arrangement also makes it possible with the aid of a cotton holder to apply acids, caustics, etc., exactly on the spot where their effect is most wanted, or with a pair of forceps to seize foreign bodies in the œsophagus, urethra, etc. It is chiefly employed for lighting up the male urethra, the ear, nose, œsophagus, rectum and vagina.

No. 1257. Complete set, consisting of the above instrument, with spare lamp in case, 5 urethral tubes and 2 cotton holders £5 12 0

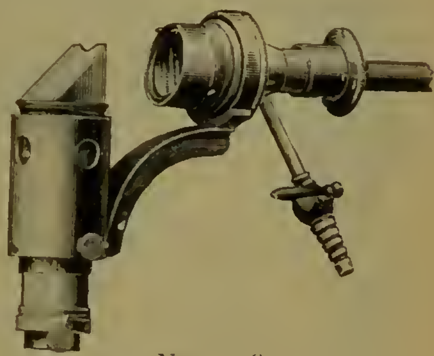


No. 1258.

With the Urethroscopes it is very essential that the lamp should be exactly in the focus of the mirror or lens, as otherwise no light will be obtained at the end of the tube. This must be borne in mind in placing new lamps in their position. After exchanging the lamps, a piece of white paper is placed on a table, and the end of the tube directed upon this paper. Now, while the lamp burns, it is moved up and down, until an intense and circular light falls on the paper, and when in this position it is fixed to the body of the instrument by means of a screw.

No. 1258. **Schall's Urethroscope** (Patent No. 1725, '96), with spare lamp and cords, Fig. 1258 ... £2 12 0

No. 1258A. The same instrument, with the inflating arrangement and double bellows in addition ... 3 9 0



No. 1258A.

No. 1259. Complete set, consisting of instrument No. 1258, in case, with 3 tubes and 2 cotton holders £3 9 0

No. 1259A. Complete set, consisting of instrument No. 1258A, in case, with 3 urethral tubes and 2 cotton holders ... 4 4 0

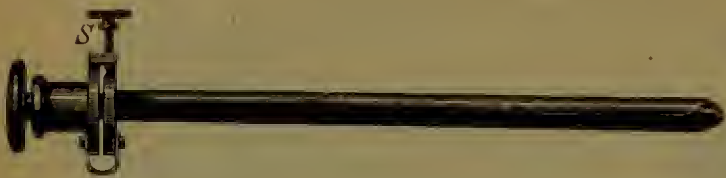
This instrument has the same advantages as No. 1256, but the light is utilised in a more economic manner, and the illumination at the end of the tube is therefore more intense.

No. 1261.

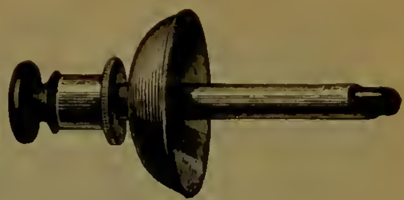
No. 1261.	Urethral Tube, No. 16 French gauge, $3\frac{1}{2}$ inches long, Fig. 1261	4/-
No. 1262.	Do. No. 18 French gauge, 4 ins. long	4/-
No. 1263.	Do. No. 20 ,, ,, $4\frac{1}{2}$,, ,, ...	4/-
No. 1264.	Do. No. 22 ,, ,, 5 ,, ,, ...	4/-
No. 1265.	Do. No. 24 ,, ,, 5 ,, ,, ...	4/-
No. 1266.	Do. No. 26 ,, ,, 5 ,, ,, ...	4/-

Other sizes and lengths of tubes are made to order.

Similar tubes, with cups, as shown in Fig. 1269, 5/- each.



No. 1270.



No. 1269.

No. 1270. Urethral Tubes, lengthwise, open ... ... each 8/-

No. 1272. Tubes for the prostate, with conductor ... .. ,, 6/-

No. 1280. Cotton holders for the urethra ... ... ,, 2/-

No. 1304.

No. 1290.

No. 1290. Rectal Tube, with conductor, in three different sizes ... ... each 4/6

No. 1294. Metal Ring, to connect these tubes with the Urethroscope ... ... each 3/-

For illuminating the ear and nose, funnels of different diameter can be screwed on to the instrument.

No. 1296.

No. 1300.

No. 1296. Ear Funnel, in three different sizes, Fig. 1296 each 2/-

No. 1300. Tube for examining the nose, Fig. 1300 ,, 3/6

No. 1304. Tube for examining the œsophagus, diameter 15 mm., length 11 ins., Fig. 1304 each 11/-

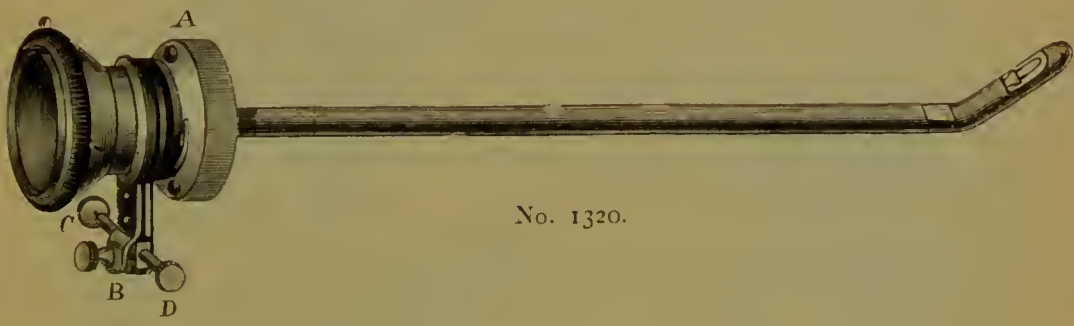
No. 1306. Tube, diameter 17 mm., length 18 in. ,, 14/-

No. 1307. Metal Ring, to connect the œsophagus tubes with the urethroscope ... ... each 4/-

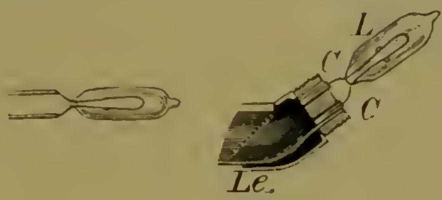
No. 1310. Forceps, for the œsophagus, by Boecker ,, 35/-

With such a pair of forceps an artificial set of teeth has been removed from the œsophagus, in Prof. v. Billroth's clinique.

Cystoscopes.—The Cystoscopes made by Leiter are now universally recognized as the best make. In Great Britain there are over 500 of them in use; this is, no doubt, the best proof of their usefulness and reliability. They are being used by all the well-known specialists for diseases of the bladder, and in all the larger hospitals.



No. 1320.



They consist of a tube bent at the end like a calculus sound. In this part of the instrument the lamp is placed, specially protected by a thick window of rock crystal. To exchange a lamp, the bent part of the instrument is unscrewed, the lamp taken out and a new one put in its place. Screw B opens and closes the circuit, and a knob indicates the part of the bladder towards which the prism is directed. By aid of the telescope, a surface of 3 to 4 inches diameter can be seen at once. The apparatus is provided, at the concavity of the elbow, with a prism. This form is most frequently used, as with its aid more than three-quarters of the bladder can be brought under examination. With it, however, the posterior wall of the bladder cannot be discerned and a second instrument is required for this purpose, the opening of which is on the convexity of the elbow. A simple glass window here takes the place of the prism, through which the direct observation of the posterior wall of the bladder becomes possible. This latter apparatus is only to be used for examinations of the posterior wall and base of the bladder.

The telescope can easily be taken out and replaced, so that one telescope serves for two instruments.*

No. 1320. **Hurry Fenwick's Cystoscope,** for anterior wall, with telescope and one spare lamp, Fig. 1320 ... ...£4 15 0

No. 1321. Ditto, for posterior wall, with one spare lamp 2 12 0

The lamps require 7 volts and 1·2 ampère.

This instrument is the most recently improved Cystoscope. The connecting cords are fastened so that they revolve easily, and there is, therefore, no impediment in turning the instrument. The beak is short.

* For uses, *vide* "Electric Illumination of the Bladder and Urethra" (E. Hurry Fenwick), second edition, 1889; "British Medical Journal," No. 1424, and "Lancet," No. 3378.

No. 1323. **Hurry Fenwick's Straight Cystoscope,** with separate catheter. The catheter is introduced first, the bladder is washed out then, and the Cystoscope is inserted through the catheter. Price, with telescope and one spare lamp £5 5 0

The usual diameter of the Cystoscope is No. 22 French gauge. They can, however, be supplied as thin as No. 18 French gauge, or as thick as No. 40—in the latter case the illumination is brighter, and a larger surface is visible at a time.

Cystoscopes provided with an arrangement for taking photographs of the living bladder can be supplied to order. Prices on application.

The usual length of that part of the instrument which can be introduced through the penis is 7½ inches, but any length can be supplied to order. It is, however, well to remember that the longer and thinner the instrument, the smaller and darker must be the picture, and *vice versâ.*

The Cystoscope lamps require about 8 volts and 1·3 ampère.

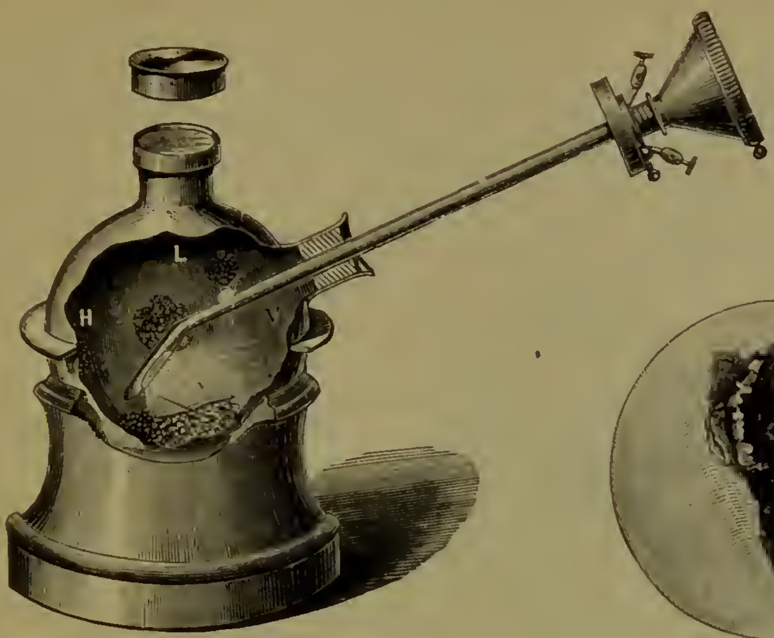
No. 1322. Case for Cystoscopes £0 10 0

No. 1325.

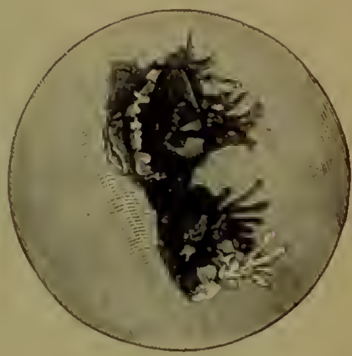
No. 1325. **Casper's Cystoscope,** for introducing a catheter into the urethra, with lamp and case, Fig. 1325 ... ...£8 6 0

Cystoscopes must not be left burning for any length of time in the open air, as in that case they would get heated, and the insulation of the electric conductor might be destroyed. If, however, that part of the apparatus containing the lamp is surrounded by water, the Cystoscope may be kept burning for hours before it becomes perceptibly warm.

To be examined with a Cystoscope the bladder always ought to contain 5—8 ounces clear water. If the water in the bladder is not clear, it ought to be rinsed out previous to the operation.



No. 1329.



No. 1343.

No. 1329. For practising with Cystoscopes and for demonstrations, a Phantom as shown (Fig. 1329), exhibiting artificial tumours, stones, and foreign bodies, &c., is very convenient £0 18 0

No. 1343 shows two blood-red villous papillomata, of the exact size seen by a Leiter Cystoscope in a lady aged 50, who has suffered many years from painless hæmaturia. It was modelled according to the plan recommended by Mr. Hurry Fenwick ("Brit. Med. Journ." Jan., 1889).

No. 1330. **Gastroscope,** with telescope £9 10 0

This apparatus is essentially of the same construction as the Cystoscope.

No. 1332.

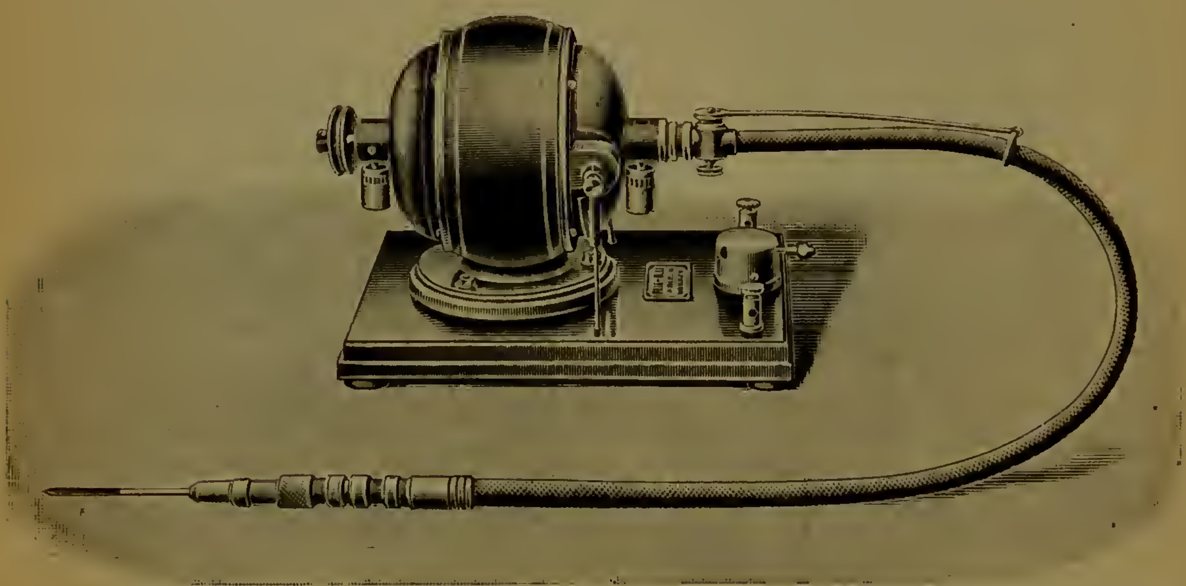
No. 1332. Instrument for making the stomach transparent, with spare lamp, Fig. 1332 ... ... £3 12 0

To utilize this apparatus, the stomach is emptied, and filled with water: the instrument, which is as flexible as an indiarubber tube, is then swallowed, and shows in a dark room the exact position, size and shape of the stomach.

Surgical Lamps to be used in connection with the 100 to 250 volt currents supplied from dynamos will be found under Nos. 1710—1735 on pages 141—143.

MOTORS.

When ordering motors, please state whether they are to be worked with batteries (accumulators Nos. 916—933, bichromate batteries Nos. 1003—1010 or 1042) or with the current supplied for lighting houses. In the latter case, please state whether it is a continuous or alternating current, and the voltage of the supply.



No. 1351.

No. 1351. **Powerful Surgical Motor** of about 0·2 H.P. for working drills, trephines, circular or straight saws; for applying massage in nose, ear, etc., and for applying rapid vibrations to joints. It can be wound either for 10, 100 or 220 volt continuous current. This type of motor starts in any position. If the foot switch is used, it stops the moment the current is broken, and, by reversing the current, the direction of rotation is reversed **£7 10 0**

Two smaller sizes of this kind of motor can be supplied for **£5 10s.** and **£6 15s.** respectively.

These motors are also suitable for driving static machines, fans, centrifugal machines, various pumps, etc.

As supplied to the Royal Infirmaries in Edinburgh and Glasgow, Western Infirmary, Glasgow; Royal Infirmary, Sheffield; Royal Free Hospital, St. Bartholomew's Hospital, Poplar Hospital, London. Drs. F. M. Mackenzie, Greville MacDonald, C. H. Cosens, Pepperdene, E. Law, Eve, etc., etc.

No. 1352. Powerful flexible cable and universal hand piece, to fit the above motor, as shown on illustration 1351 ...**£3 0 0**

No. 1354. Foot contact, for starting or stopping the motor (see illustration 1442, page 123) **1 16 0**

No. 1355. Similar motor, largest size of 0·5 H.P. with cable and hand piece of suitable strength **£30 0 0**

As supplied to the General Hospital, Birmingham. With a motor of this size, it is possible to use *conical* trephines of $1\frac{1}{2}$ in. diameter for perforating the skull, and even with trephines of such a diameter, this size motor does not stop.

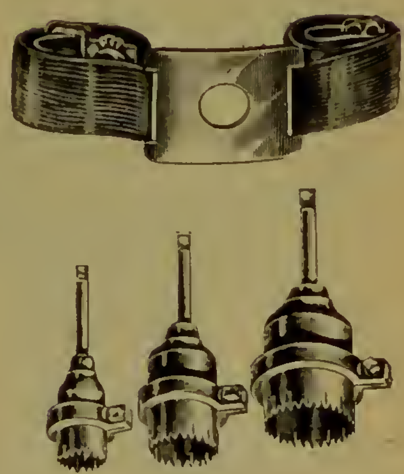
No. 1360. Rheostat for starting and controlling the speed of motors to be used with currents of 100 to 200 volt **2 0 0**

To control the speed of 10 volt motors, a rheostat No. 981 is required.

Hand piece. Burrs. Drills. Trephines.

Sounds for Massage.

Plates for rapid vibration.

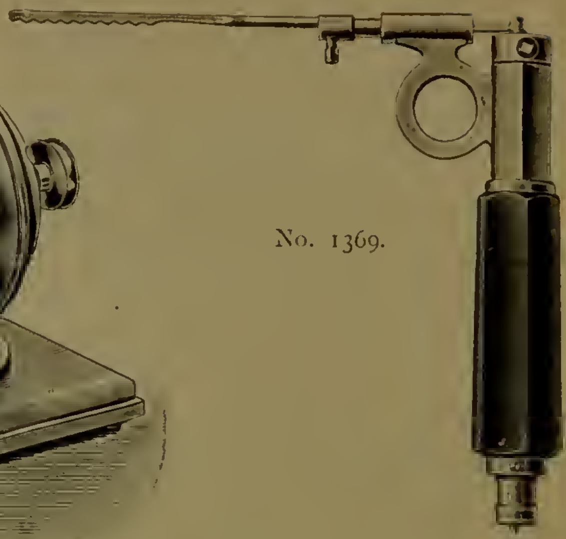


Trephines.

These illustrations show some burrs, drills, trephines, sound for massage, and plates for applying rapid vibrations to joints, etc.

Prices of drills and burrs vary from ... ... **2/- to 4/6**
,, straight saws, trephines, and circular saws ... **5/- to 10/-**
,, large conical trephines vary from ... ...**25/- to £2 10s.**
,, plates for applying rapid vibrations to joints ... **5/- to 16/-**

No. 1375.

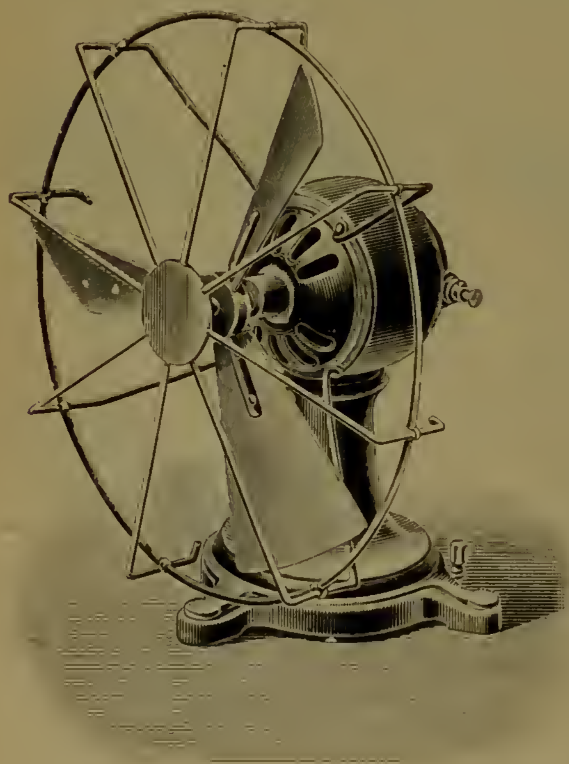


No. 1369.

No. 1369. Handle, for converting a circular movement into a longitudinal one, for straight saws, massage, percuteur, etc., Fig. 1369 ... ... **£2 10 0**

This handle can be attached to the surgical hand pieces. The length of the stroke can be varied.

No. 1375. Powerful Motor, wound for 10, 100, or 200-volt continuous current, for driving static machines, etc., Fig. 1375, made in three sizes ... **£5, £6** and **£7 0 0**



No. 1390.

No. 1390. Motor, with fan, for ventilating consulting rooms, sick rooms, cabins, etc., Fig. 1390 ... **£4 15 0**

In ordering, please state the voltage, and whether it has to be used on continuous or alternating current circuits.

For **Motor interrupters,** see Nos. 1520—1521, page 126.

For **Motor transformers,** see Nos. 1664—1668, page 138.

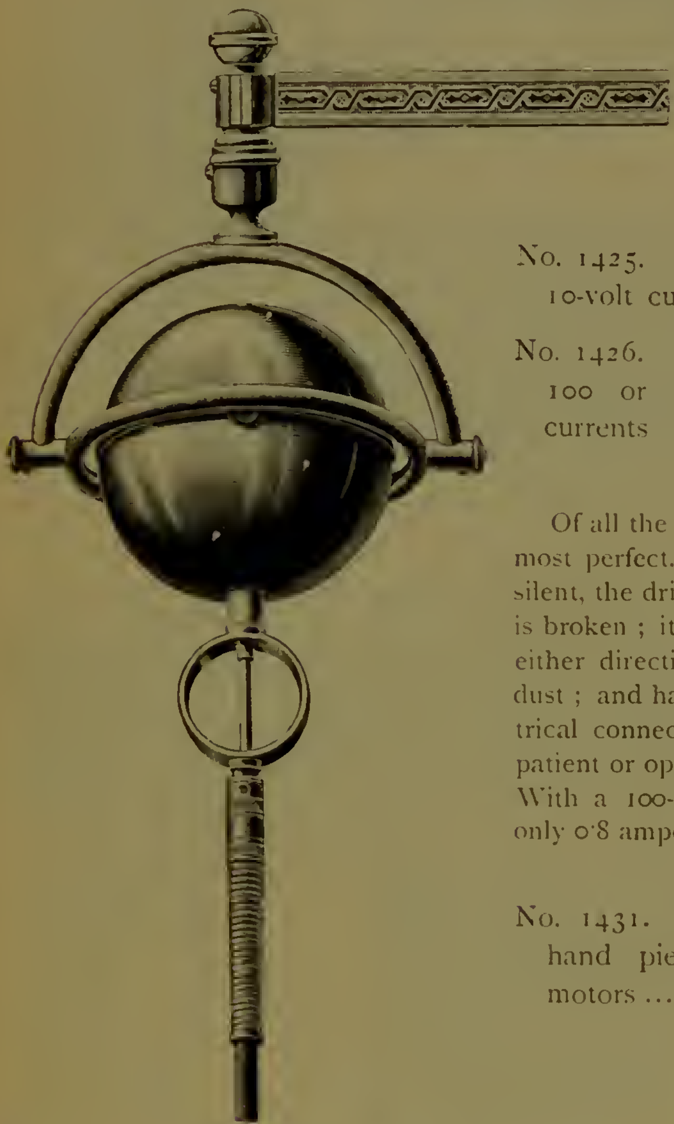
For **Motor for sinusoidal currents,** No. 1679, page 138.

For **Motor for pneumatic massage of the ear,** No. 2030, page 150.

For **Motor for driving centrifugal machines,** No. 2027, page 150.

For **Motor for dental purposes,** No. 1426, page 123.

DENTAL MOTORS AND INSTRUMENTS.



No. 1426.

No. 1425. Columbia Motor for 10-volt currents £8 0 0

No. 1426. Columbia Motor for 100 or 200-volt continuous currents 8 8 0

Of all the existing dental motors this is the most perfect. It is very powerful, perfectly silent, the drill stops the moment the current is broken ; it starts in any position and runs in either direction. It is well protected against dust ; and hand piece and drill are in no electrical connection with motor or earth, so that patient or operator cannot receive any shocks. With a 100-volt supply the motor consumes only 0·8 ampère.

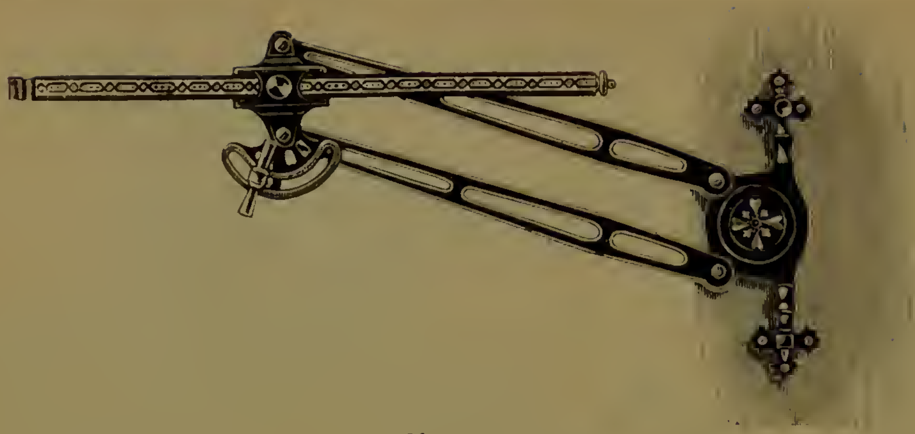
No. 1431. Flexible shafts and hand pieces for the above motors ... from £1 16 0 to £3 0 0

No. 1440.

No. 1440. Foot contact, to start, stop, or reverse the motor, with rheostat to control the speed ...£5 15 0

No. 1442.

No. 1442. Foot contact, to start or stop the motor £1 16 0



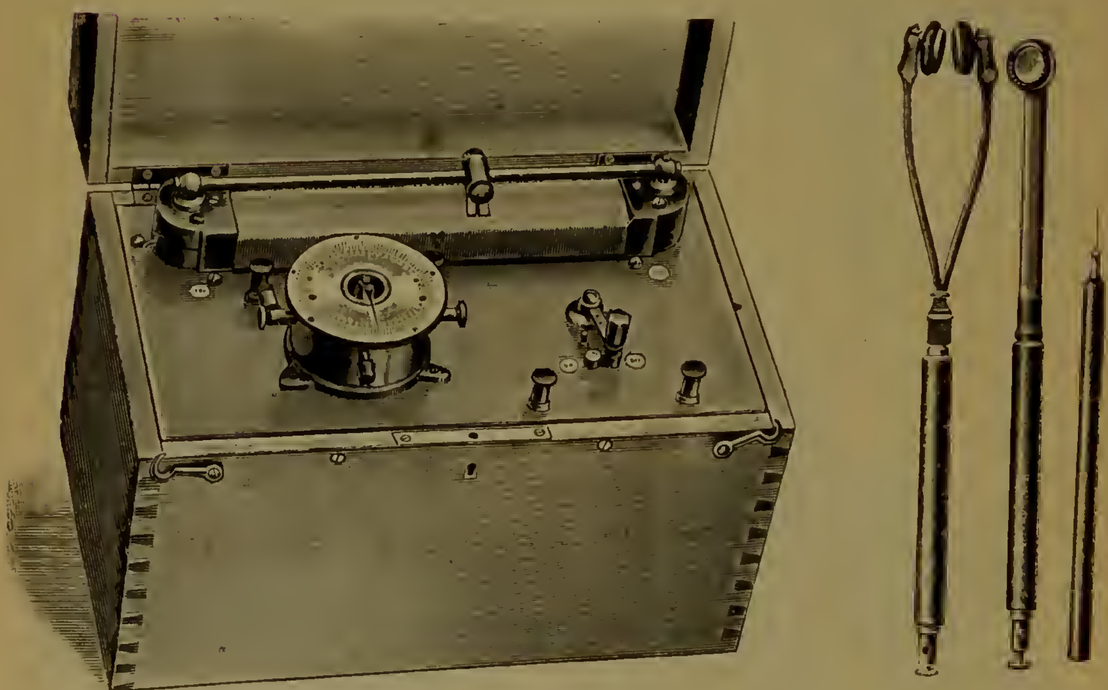
No. 1450.

No. 1450. Bracket for suspending the Columbia motor £3 10 0

No. 1454. Heavy stand for suspending the motors 1425—1426 ... 3 10 0

(Illustration on application.)

No. 1460. Complete outfit **for Catophoresis,** consisting of 18 large Leclanché dry cells in walnut case, volt regulator increasing or diminishing the E.M.F. by 0·1 volt at a time, galvanometer registering up to 6 M.A. every $\frac{1}{10}$th of a M.A., switch to break the current automatically when the lid is closed, cords, wrist electrode, electrode with platinum point for cavities, one single pole and one double pole electrode for the reception of amadou discs soaked in cocaine and guaiacol 9 0 0



No. 1460.

For accumulators for dental motors ... ... see Nos. 918—925

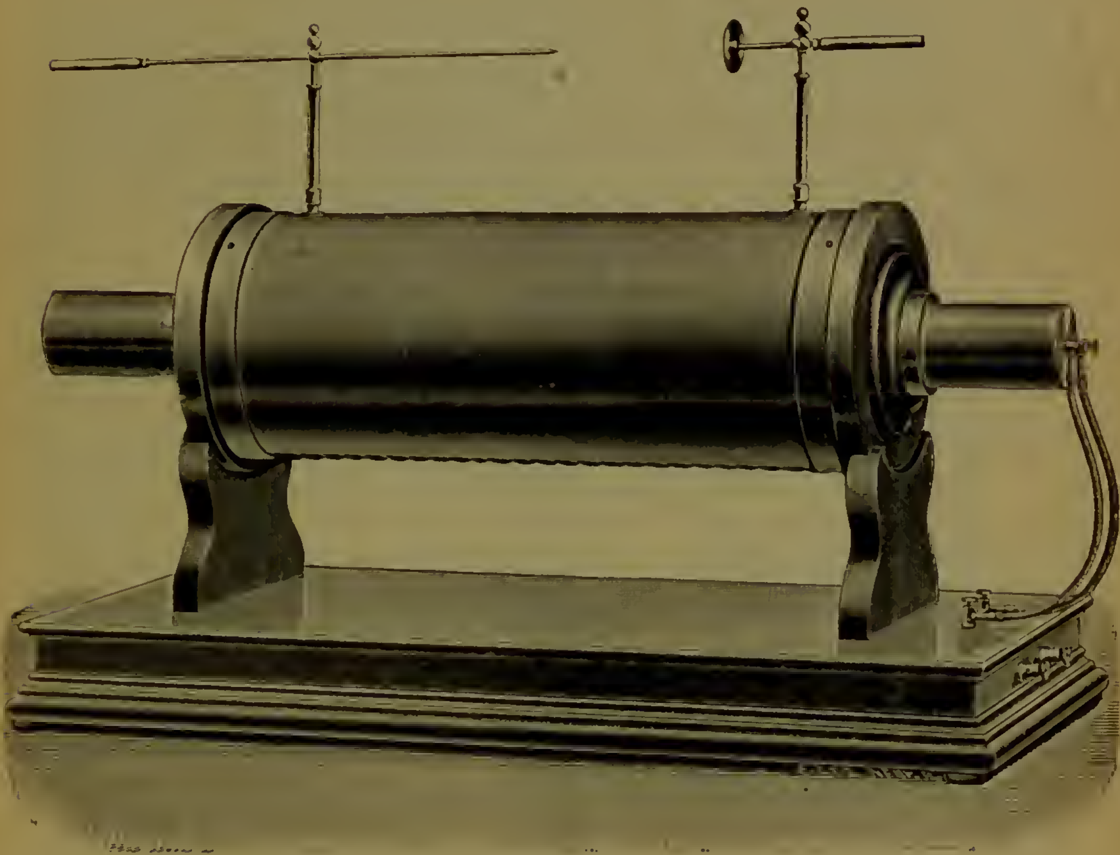
,, **cautery instruments for dental purposes** ... ,, 1117—1118

,, **lamps for dental purposes** ... ... ,, 1200—1220

,, **sterilizing and hot water apparatus** ... ... ,, 2070—2075

APPARATUS FOR PRODUCING ROENTGEN X RAYS.

(See also pages 55—65.)



No. 1511.

Spark Coils, with commutator and large condenser, in polished mahogany case. These Coils are of the best quality obtainable. We guarantee that the length of the spark stated below may be exceeded by 15 per cent. without risk of damaging the coil.

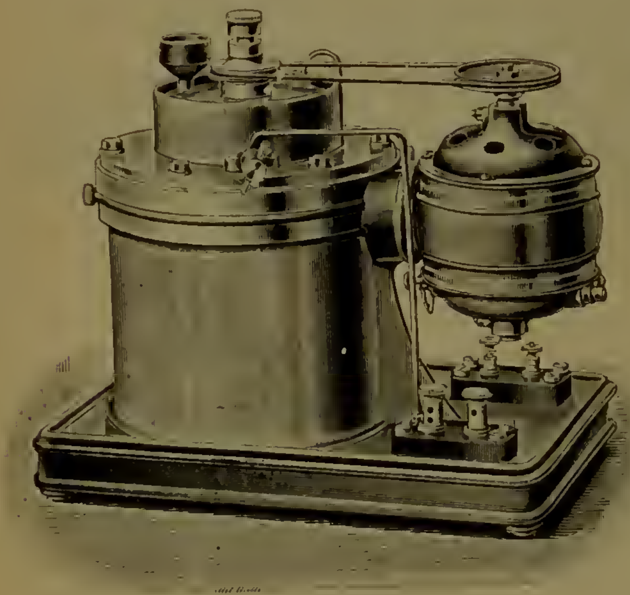
No. 1504.	6 inch spark Coil	£17	0	0
No. 1505.	8 ,, ,, ,, ...	21	0	0
No. 1506.	10 ,, ,, ,, ...	25	0	0
No. 1507.	12 ,, ,, ,, ...	36	0	0
No. 1508.	14 ,, ,, ,, ...	44	0	0
No. 1509.	16 ,, ,, ,, ...	52	0	0
No. 1510.	18 ,, ,, ,, ...	63	0	0
No. 1511.	20 ,, ,, ,, (Fig. 1511)	75	0	0
No. 1512.	25 ,, ,, ,, ...	120	0	0
No. 1513.	30 ,, ,, ,, ...	147	0	0
No. 1514.	35 ,, ,, ,, ...	192	0	0

The addition of a **mercury break** (see page 57) increases the price of coils Nos. 1504—1508 ... by 1 10 0

,, ,, **platinum break** increases the price of coils Nos. 1504—1508 ... ... by 2 5 0

For larger coils, we advise strongly the interrupters mentioned below ; they can, of course, also be used with advantage for smaller coils. If the 100 or 200-volt continuous current is available, we recommend Nos. 1521 or 1522 ; if the coil has to be worked by accumulators or primary batteries, we recommend Nos. 1520 or 1522.

No. 1520. **Dr. Mackenzie Davidson's Motor interrupter,** with rheostat to regulate the speed of the motor (see page 59) **£5 5 0**



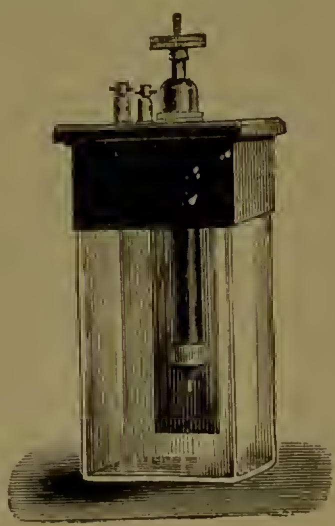
No. 1521.

As supplied to : Royal Infirmaries, Edinburgh and Glasgow ; Western Infirmary, Glasgow ; Drs. C. H. Cosens, F. M. Mackenzie, Pepperdene, etc.

No. 1521. **Turbine interrupter,** Fig. 1521, with rheostat for controlling the speed of the motor (see page 59). **£12 0 0**

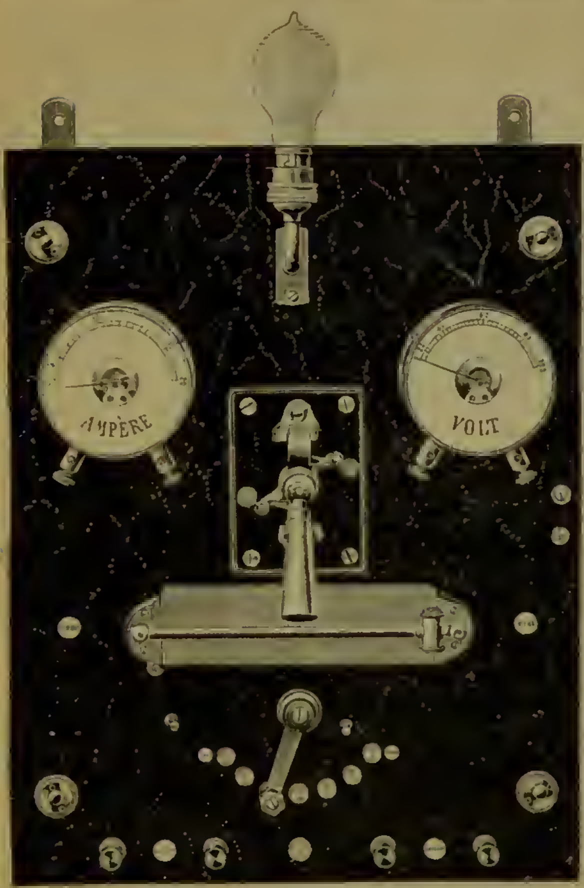
No. 1521A. Similar interrupter, with alternating current motor, to use a spark coil directly from alternating current supply of 100 volts **£17 10 0**

The number of sparks can be varied between 1,500 and 7,000 per minute. The light of the Crookes' tubes is absolutely steady.



No. 1522.

No. 1522. **WEHNELT'S ELECTROLYTIC INTERRUPTER, with variable surface of the active platinum electrode,** improved type, to prevent leaking, Fig. 1522. (See page 58) **£3 0 0**



No. 1525.

No. 1525. **Rheostat, with shunt circuit to vary the number of volts, for spark coils** (Fig. 1525), for 110 volt circuits £11 0 0

No. 1526. Similar rheostat, wound for 200 to 250 volt circuits ...14 0 0

The rheostats may also be used for cautery burners.

The addition of a voltmeter and ampèremeter, as shown in illustration 1525, increases the price by £4.

(See also page 58.)

The strength of the current can be varied in these rheostats between 4 ampères and 16 ampères, and the E.M.F. can be adjusted by turning the crank, so that either 20, 30, 40, 50, 60, 70 or 80 volts are available at the terminals. This makes these rheostats specially adapted for use with a Wehnelt or other electrolytical interrupter, or with Mr. Mackenzie Davidson's new motor interrupter (see page 59). If 100 or more volts were used with these interrupters, the tubes would be destroyed very quickly, but if the number of volts is reduced the discharge is perfectly under control, and can be adapted to the various tubes, so that they will last with the new interrupters as long as with the old platinum or mercury interrupters, with which the rheostat can be used as well.

Dr. Mackenzie Davidson writes us about the rheostat: "I am very pleased with your rheostat. I tried it with the new electrolytical interrupter with most excellent results."

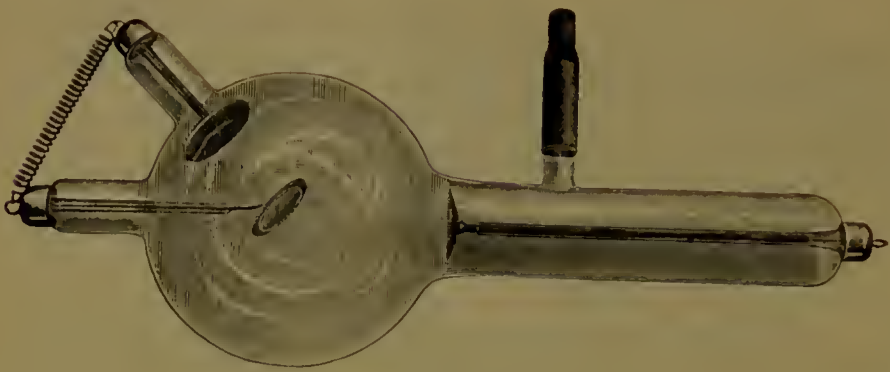
We have supplied rheostats with variable number of volts for spark coils amongst others to: Drs. Mackenzie Davidson, John Macintyre, F. M. Mackenzie, W. V. Furlong, Charing Cross Hospital, Royal London Ophthalmic Hospital, Queen's Hospital, Birmingham; Royal Infirmary, Hull: West Riding Asylum, Wakefield; Radcliffe Infirmary, Oxford; Norwich Hospital, Sydney Hospital, etc., etc.

No. 1528. Flexible braided silk cable 12 feet long, with india-rubber insulation and terminals at the four ends, suitable to carry currents up to 20 ampères, to connect spark coils with batteries, rheostats, volt selectors, &c. ... £0 9 0

For **accumulators for working spark coils**, see No. 933.

For **bichromate batteries for working spark coils**, see Nos. 1003—1010, and 1042.

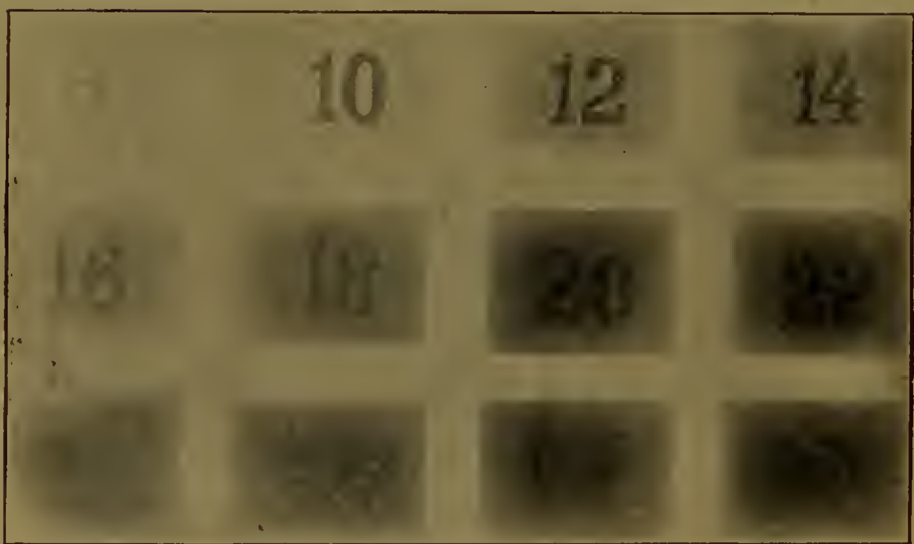
For **rheostats for utilizing currents from dynamos for spark coils**, see also Nos. 1642—1645.



No. 1532.

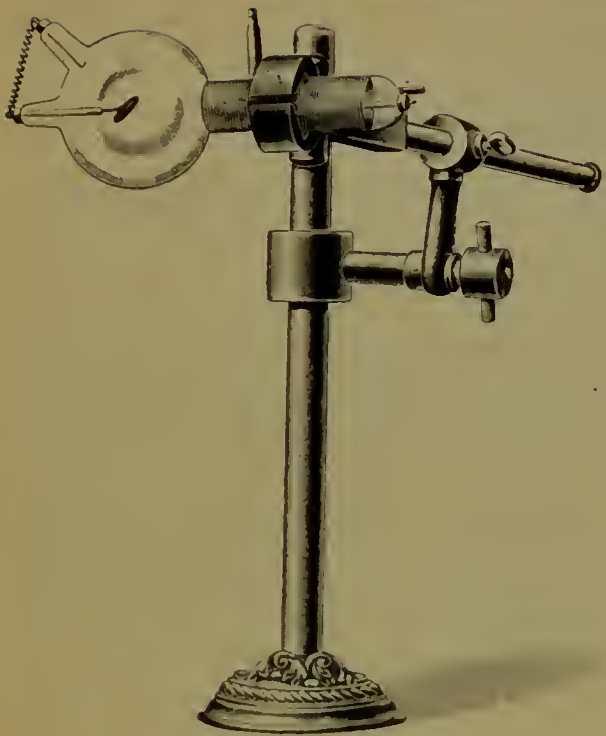
Focus tubes of best quality, with two anodes—

No. 1530.	Diameter of bulb, $3\frac{1}{2}$ inch, for	4—10 inch sparks	...	£1	0	0
No. 1532.	„ „ 5 „	6—15 „	...	1	6	0
No. 1534.	„ „ $6\frac{1}{2}$ „	12—30 „	...	2	2	0



No. 1536.

No. 1536. **Actinometer,** for testing accurately the penetrating power of focus tubes (see illustration No. 1536) ... £1 5 0



No. 1539.

No. 1539. Stand with an insulating arm 28 in. long, and convenient clamp to hold the tubes, heavy cast-iron foot, Fig. 1539 ... **£1 15 0**

No. 1540. Large stand. 5 feet high, with insulating arm ... **£2 12 0**

Fluorescent Screens for direct observation, coated with two thick layers of large crystals of barium platino-cyanide:—

No. 1550. 5 × 7 ins.	... **£1**	**5**	**0**
No. 1552. 7 × $9\frac{1}{2}$ ins.	... **2**	**0**	**0**
No. 1553. $9\frac{1}{2}$ × 12 ins.	... **3**	**3**	**0**
No. 1554. 12 × $15\frac{1}{2}$ ins.	... **5**	**0**	**0**
No. 1556. **Cryptoscope,** with a screen, Fig. 1556... ...	... **3**	**0**	**0**

No. 1556.

The Screens 1550—1558 can be supplied with a frame and cover, which will fit tight into the frame, so that a casette is formed for the reception of photographic plates. *The same screens which serve for direct observations, are then available as accelerating screens, too.*

No. 1557. Double-coated Platinum Screens, with special frame and cover, for the reception of plates, $6\frac{1}{2} \times 8\frac{1}{2}$ ins. **£2 8 0**

No. 1558. Double-coated Platinum Screens, with special frame and cover, for the reception of plates, 10 × 12 ins. ... **3 16 0**
Other sizes can be made to order.

K

PHOTOGRAPHIC MATERIALS.

Dry Plates, Films, or Papers of any maker are supplied to order at the list prices charged by the makers.

In ordering plates, please state whether you desire medium, rapid, or instantaneous plates (see page 64).

Light-tight yellow and black Envelopes, for protecting plates against daylight during exposure, $6\frac{1}{2} \times 8\frac{1}{2}$ ins., **2**/- ; 8×10 ins., **3/6** ; 10×12 ins., **6**/- ; 15×12 ins., **10**/- per dozen.

Developing Trays, Porcelain Dishes, Printing Frames, Boxes for storing negatives, **Ruby Lamps, Glass Measures, Chemicals, Developers,** etc., supplied to order.

No. 1570. **Set of Photographic Utensils** for plates up to 8×10 ins., consisting of 1 xylonite and 2 porcelain dishes, 10 oz. graduated measure, and ruby lamp ... **£0 15 0**

No. 1572. Similar set, but for plates up to 12×15 ins. **1 6 0**

No. 1580. **Complete Outfits for Roentgen Rays,** consisting of a 10 in. spark coil with mercury interrupter; 12-volt accumulator of 50 ampère hours capacity, rheostat to control the current; 2 focus tubes of best quality, and stand No. 1539; double-coated fluorescent screen, No. 1552; cables and connecting wires, and a set of photographic utensils, No. 1572 ... ... **40 0 0**

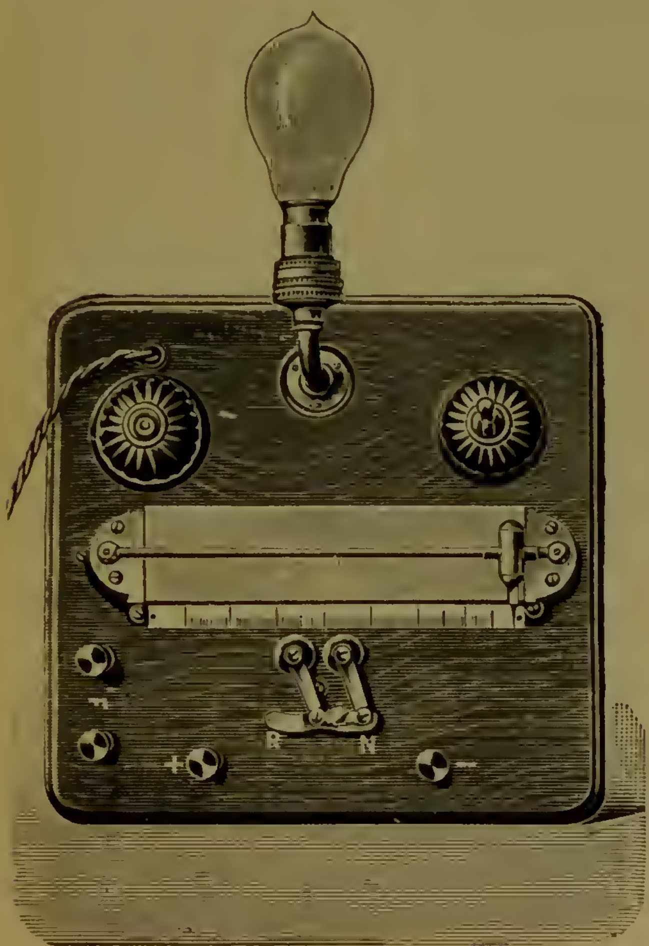
Estimates for complete sets with other sizes of Coils, can be had on application.

APPARATUS FOR UTILISING CURRENTS FROM DYNAMOS FOR MEDICAL AND SURGICAL PURPOSES.

(See also pages 44—54.)

Of the following apparatus, Nos. 1600—1679 can be used in those houses where the *continuous* current is laid on. Nos. 1680—1690 can be used in houses where the *alternating* current is laid on. Nos. 1695—1840 can be used equally well with the continuous or the alternating current.

APPARATUS FOR GALVANISATION, ELECTROLYSIS, AND FARADISATION.



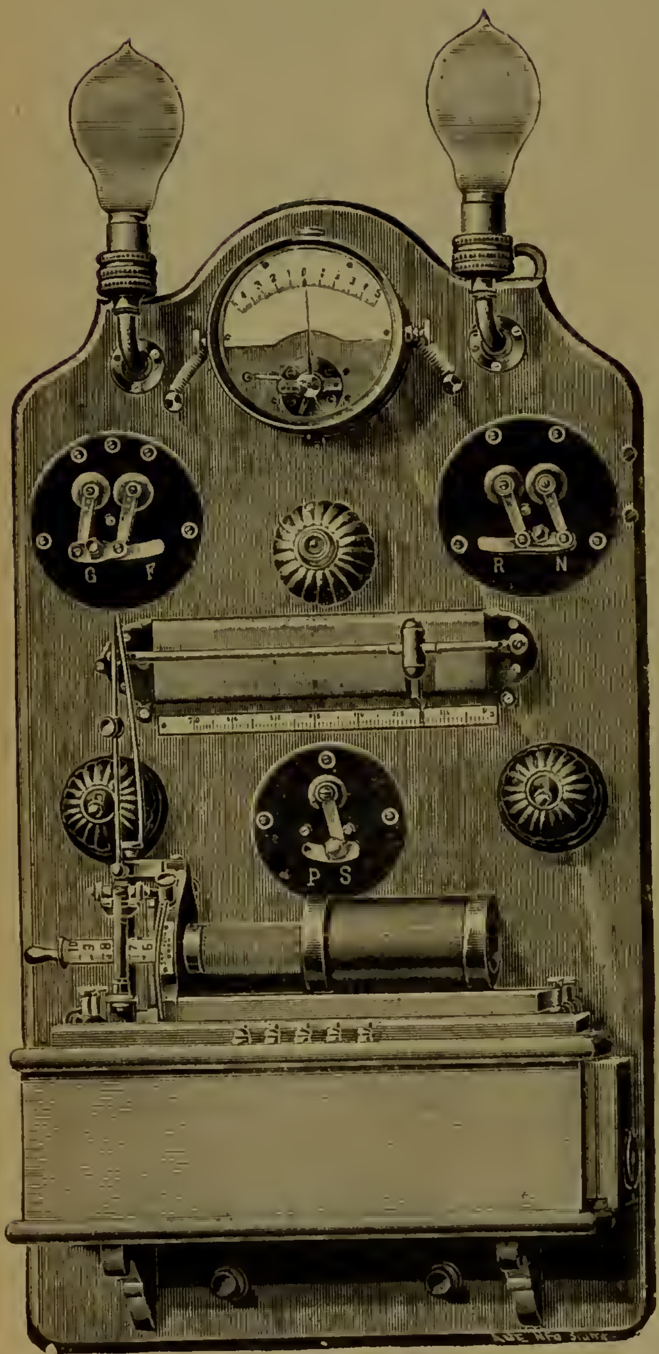
No. 1600.

No. 1600. Board of polished walnut, with switch, fuse, resistance lamp, volt regulator, 2 handles, cords and 4 electrodes, Fig. 1600 **£4 10 0**

The two terminals on the left-hand side of this board are intended for charging accumulators, or for working a faradic coil.

No. 1600 is also the most convenient apparatus for controlling the current from an alternating current dynamo for sinusoidal faradisation (see page 53).

No. 1603. Similar apparatus, but larger pattern, provided with a current reverser, and d'Arsonval galvanometer (similar to Fig. 1605) **£9 12 0**



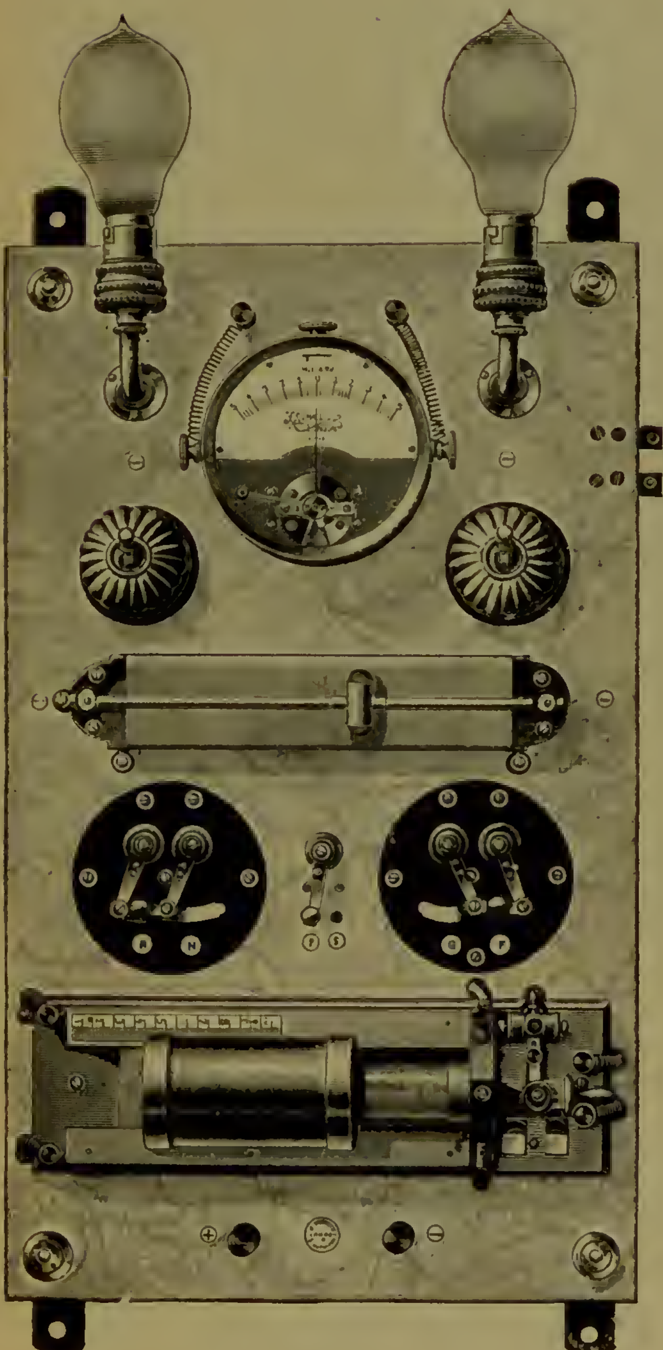
No. 1605.

No. 1605. Board of polished walnut or dark oak, with 2 switches, lamps, volt regulator, d'Arsonval galvanometer, current reverser, sledge coil No. 27, de Watteville key, cords, 2 handles and 7 electrodes; drawer for the reception of handles and electrodes, Fig. 1605 ... **£15 0 0**

As supplied to:—

Drs. Ferrier, Cavendish Square, London; Milne Murray, Edinburgh; Gage Brown, 85, Cadogan Place, London; Bickerton, Bark, Gruenbaum, Glynn, Grossmann, Liverpool; Macintyre, Bath Street, Glasgow; Dr. Brooke, Manchester; V. Cotterell, 76, Grosvenor Street; O'Connor, Arlington Street; Travers, 2, Phillimore Gardens; Stoneham, West Hampstead; Elliot, Chester; Ballance, Norwich; Furlong, Dublin; Codd, Wolverhampton.

Royal Infirmary, Hull; Smedley's Hydropathic Establishment, Matlock; Harrogate Hydropathic Co., Sussex County Infirmary, Brighton; Infirmary, Lancaster; New General Hospital, Birmingham; Royal Infirmaries, Edinburgh, Aberdeen, and Glasgow; London County Asylum, Claybury; St. George's Hospital, London; Victoria Hospital, Chelsea; Infirmary, Norwich; St. Andrew's Hospital, Northampton; Norfolk & Norwich Hospital, St. George' Hospital, Bombay; Queen's Hospital, Birmingham; West Riding Asylum, Wakefield; North-Eastern Hospital for Children, Shoreditch; Poplar Hospital, King's College Hospital, London, etc., etc.



No. 1607.

No. 1607. Similar apparatus, but mounted on a polished marble or slate slab, instead of the wooden board, Fig. 1607.

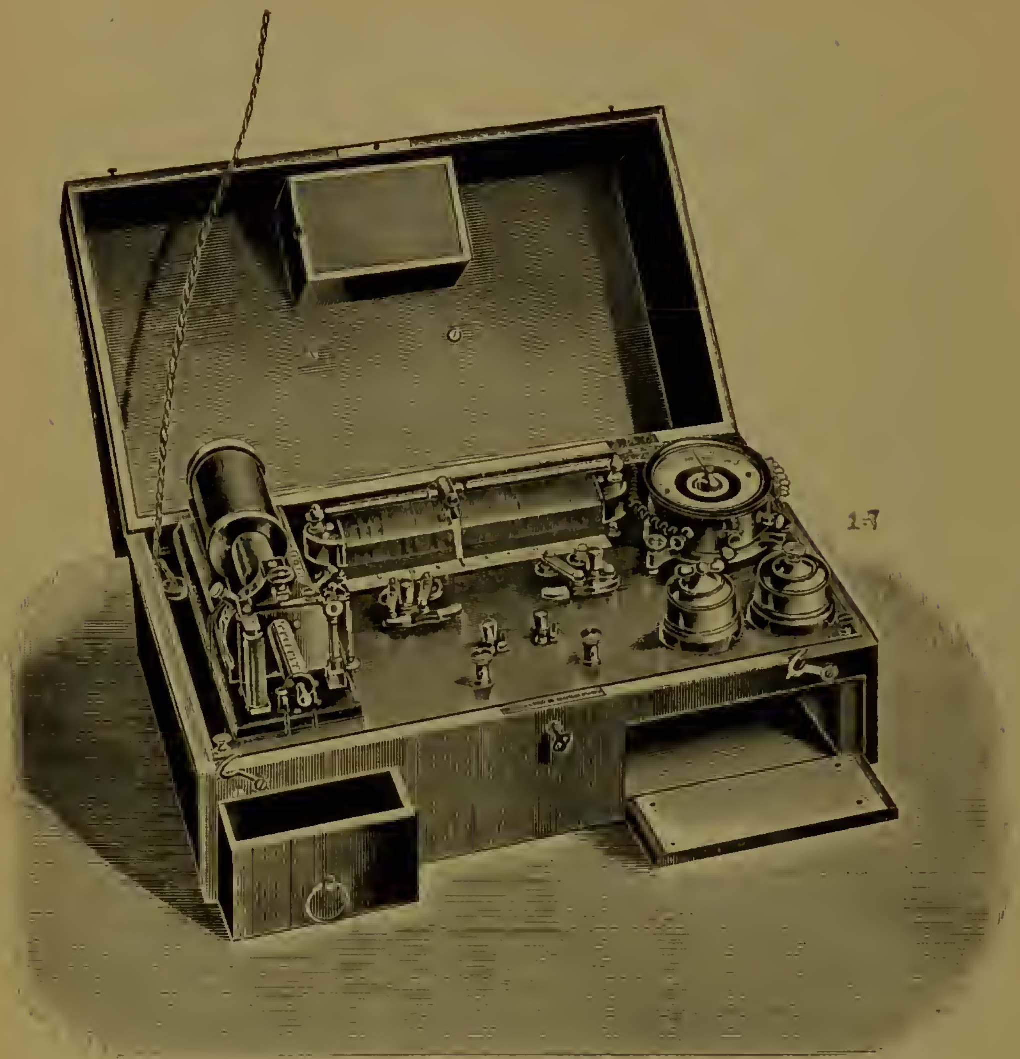
£16 10 0

If the apparatus are to be used on 100 volt supplies, it is only a matter of taste whether wood, slate, or marble is selected. But if the apparatus are intended to be used in connection with 200 or 250 volt circuits, wood ought to be avoided as much as possible, because it is an insufficient insulator for such high voltages.

The apparatus, 1612 - 1618, can also be supplied with slate or marble slabs instead of the wooden boards ; the price will be increased then about 35/-.

If the apparatus are used on 100-volt supplies, 16-candle lamps have to be used ; on 200 volt supplies, 32-candle lamps have to be used.

If desired, a cabinet with plate-glass door and a good lock can be supplied for these rheostats, price £4 10s. od.



No. 1615.

No. 1612. Portable case, containing switch, fuse, lamp, volt regulator, current reverser, galvanometer (No. 265), cords, handles, and 5 electrodes £7 16 0

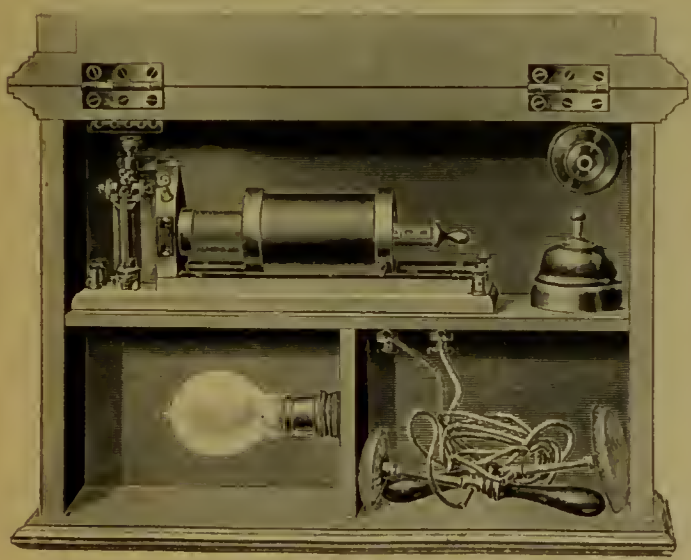
No. 1615. Portable case, with the accessories specified under No. 1605, Fig. 1615 ... ... 15 5 0

These apparatus can be carried about in the wards of hospitals, etc., and can be connected with wall plugs or lamp holders.

No. 1618. Apparatus as shown in Fig. 1618 (suggested by Dr. Milne Murray, Edinburgh) £21 0 0

This apparatus contains all the accessories specified under No. 1605, and is provided in addition with a voltmeter to show the exact E.M.F. which is being utilized on the patient.

No. 1618.

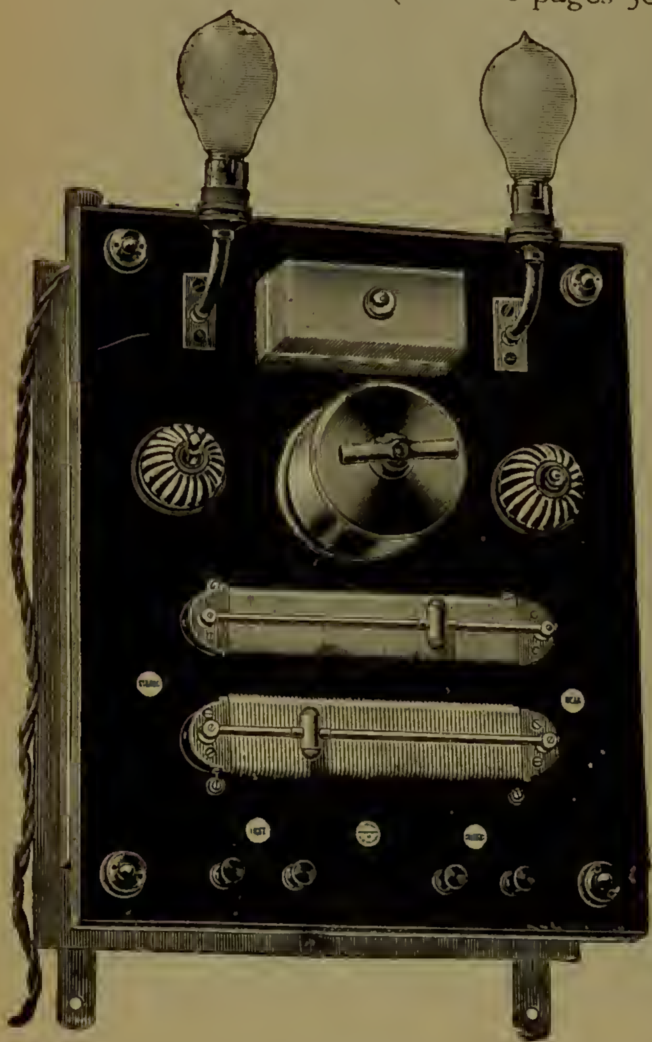


No. 1625.

No. 1625. Sledge coil, in case with glass door, for operating theatres, casualty or anæsthetists' rooms, etc., with lamp, handles and electrodes, Fig. 1625 ...£5 0 0

RHEOSTATS FOR CAUTERY AND FOR WORKING SPARK COILS FOR ROENTGEN RAYS.

(See also pages 50—51).



No. 1642.

No. 1642. **Schall's** rheostat, Fig. 1642, mounted on enamelled slate (or marble). Platinoid wire $\frac{1}{8}$ in. thick, with a total resistance of 6 ohms, 2 lamps, and 2 adjustable rheostats to vary the current without jumps, for 100 or 115 volt circuits, **£12 0 0**

No. 1643. Similar rheostat, but with a total resistance of 12 to 14 ohms, for 200 to 250 volt supplies **£14 0 0**

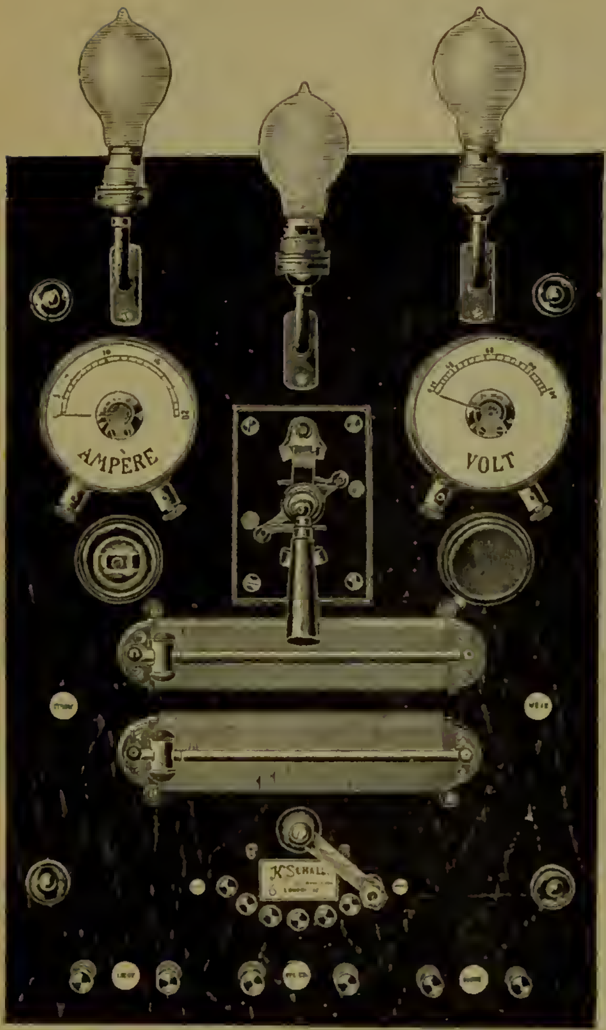
These rheostats are suitable for all cautery burners requiring between 7 and 16 ampères, for spark coils giving up to 18 in. sparks with platinum or mercury interrupters (see also No. 1525, page 127), and for all surgical lamps. If the rheostat is not wanted for lamps, the prices of 1642 or 1643 will be reduced by £1 10s.

If desired, the rheostats can be arranged on tables with trolleys for hospital use. Illustrations and prices will be sent on application.

Nos. 1642 or 1643 have been supplied amongst others to :—

Drs. Mackenzie, Hans Place ; C. L. Sansom, H. Gage Brown, W. Tyrell, F. Naumann, L. Stevens, H. Lovell, E. Cotterell, T. Fallows, G. Stoker, London ; Macintyre, Glasgow ; Milligan, Manchester ; Ballance, Norwich ; Grossmann, Bark, Bickerton, Wilson, Liverpool ; McBride, Edinburgh ; McIntosh, St. John's, Newfoundland ; Dr. Brown, Preston ; G. W. Mackenzie, William Street ; H. Symonds, Oxford.

Charing Cross, King's College, Cancer, and St. Peter's Hospitals, London ; Sussex County Hospital, Brighton ; Throat Hospital, Hartmann Street, Manchester ; Ear Hospital, Manchester ; Infirmary, Lancaster ; Victoria Hospital, Chelsea ; Royal Infirmaries—Aberdeen, Hull, Glasgow, and Manchester ; New General Hospital, Birmingham ; Norfolk and Norwich Hospital, etc., etc. Westminster Electric Supply Corporation, Metropolitan Electric Supply Company, Queen's Hospital, Birmingham ; West Riding Asylum, Wakefield ; Poplar Hospital, Royal Devon and Exeter Hospital, Royal London Ophthalmic Hospital, etc., etc.



No. 1645.

Illustration 1645 shows a rheostat similar to 1643, but with an additional arrangement to vary the number of volts, so that the rheostat can be utilized too for a spark coil with an electrolytical or Mackenzie Davidson's interrupter (see pages 58 and 59). The addition of the arrangement to vary the number of volts increases the price of rheostats 1642 or 1643 by **£2 15 0**

The addition of ampèremeter and voltmeter, as shown on Fig. 1645, increases the price of rheostats 1642 or 1643 by **£4 0 0**

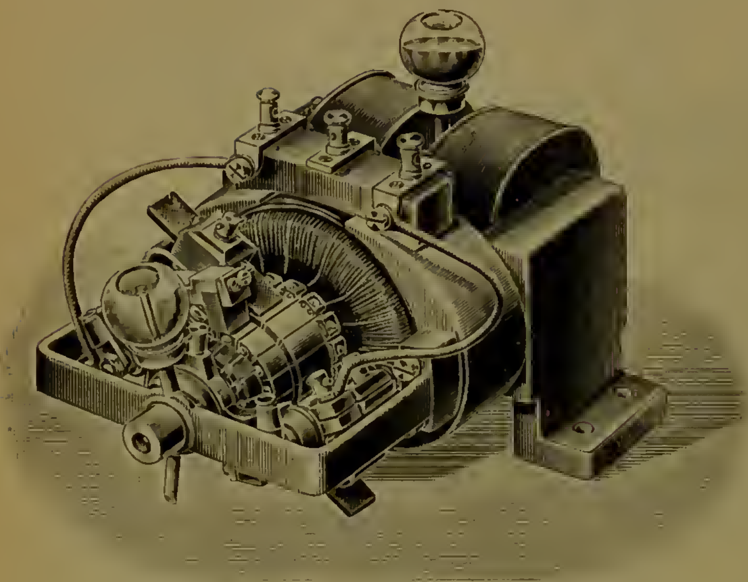
Some doctors seem to be under the impression that, in using cautery burners, etc., it is more advantageous to charge accumulators than to use the current directly with the help of a rheostat. A calculation will show, however, that this is erroneous.

In order to charge an accumulator of 35 ampère hours capacity from a 100-volt supply, the accumulator has to be inserted for 17 or 18 hours in the circuit of a 50-candle lamp, an expenditure of 3·6 units. Under the most favourable circumstances, *i.e.*, if the accumulator is discharged within the next fortnight, about 80 per cent. of the stored-up electricity may be recovered, and the accumulator may keep a cautery burner requiring 15 ampères incandescent for two hours. A rheostat allows a current of 16 ampères to pass, and consumes 3·3 units to keep the same burner incandescent for two hours. The rheostat consumes this current from the moment the switch is turned on till it is turned off again, and with carelessness this may cause waste; accumulators, on the other hand, discharge slowly, and to keep them in good condition they must be recharged, whether they are being used or not (see page 29), and this means waste of time and current. Moreover, the plates of the accumulators have to be renewed from time to time, whereas the rheostats do not deteriorate and require no repairs.

If the only consideration were the account with the Electric Light company, it would be difficult to decide whether an accumulator or a rheostat is more economical, but if convenience, cleanliness, and reliability are concerned as well, there is no doubt whatever that a rheostat is much preferable to an accumulator.

MOTOR TRANSFORMERS.

(See also page 51.)



No. 1664.

No. 1664. Motor transformer, Fig. 1664, for converting a current of 100 volts and about 1·75 ampères, or 200 volts and 1·0 ampère into a current of 10 volts and 10 ampères (100 Watt) £22 10 0

No. 1666. Similar transformer, but larger size to supply a current of 170 Watt £28 0 0

No. 1668. Similar transformer, large size, to supply a current of 600 Watt (either 30-volt and 20 ampères or 44-volt and 14 ampères, etc.) 46 0 0

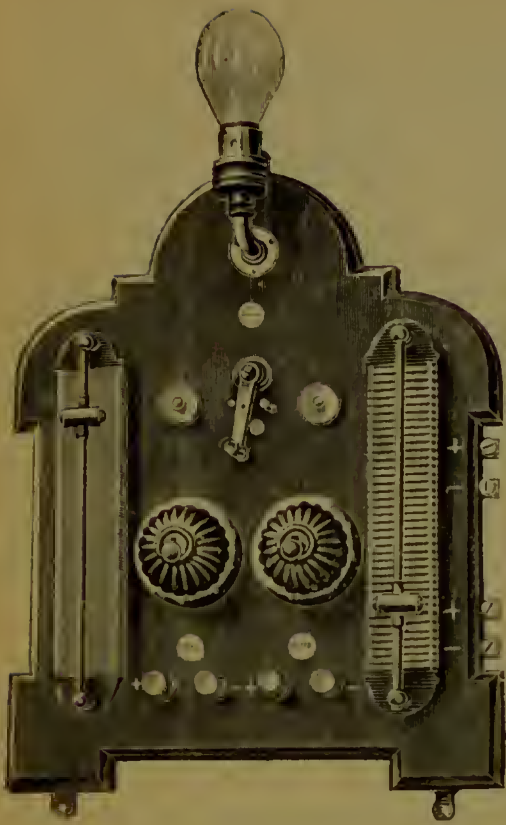
(As supplied to the Royal Infirmary, Edinburgh.)

The prices quoted for 1664—1668, include the rheostat required for starting and regulating the speed of the transformers. They may be used for charging accumulators, or for working cautery burners or spark coils directly. They can also be used with saws, trephines, etc., for surgical operations.

No. 1679. Motor, for converting a continuous current into a sinusoidal current, including rheostat for regulating the speed £12 10 0

(As supplied to Dr. Milne Murray, Edinburgh ; West Riding Asylum, Wakefield, etc.)

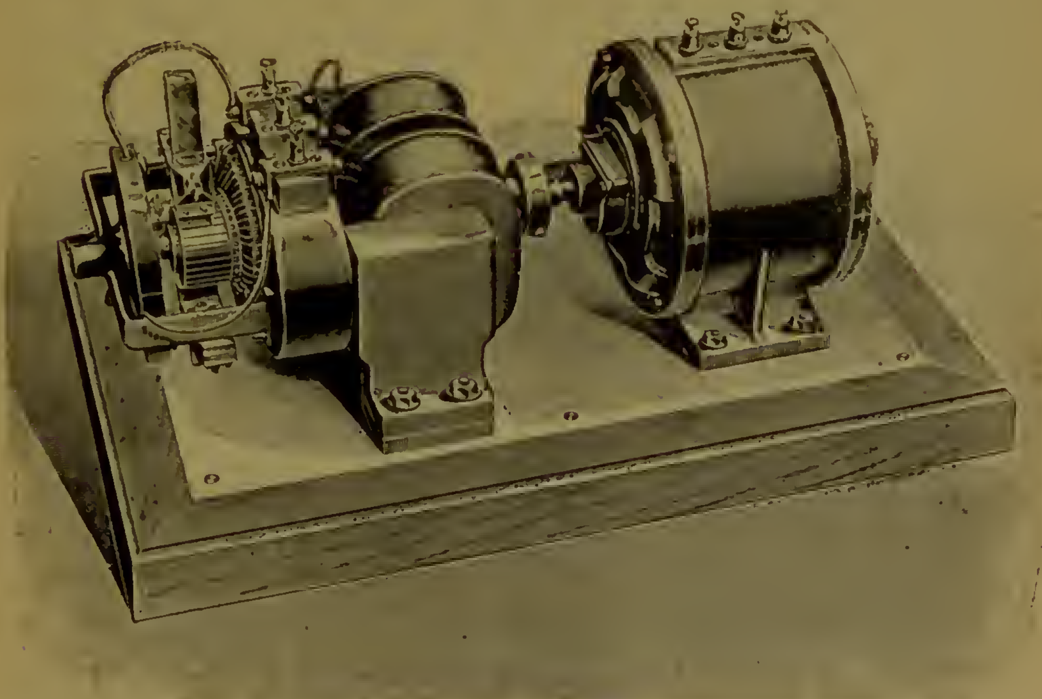
No. 1679.



No. 1675.

No. 1675. Rheostat, Fig. 1675, for utilising 100 to 250-volt continuous currents *with the help of accumulators* for cautery, exciting spark coils, and for surgical lamps. The board is provided with switch, fuse, lamp, and two rheostats for controlling the discharging current £4 0 0

To utilize this apparatus for cautery an accumulator, No. 931, is wanted in addition. To utilize it for cautery or spark coils an accumulator No. 933, is to be used. The prices of the accumulators are not included in the price quoted above.



No. 1690.

No. 1690. Motor transformer, for converting an alternating current into a continuous current (see page 54). Prices for the various sizes on application.

ALTERNATING CURRENT SUPPLIES.

(See also pages 52—54.)

No. 1680.

No. 1680. **Schall's Portable Transformer,** Fig. 1680, for cautery and surgical lamps, on polished slate plate. The current for cautery can be varied between 6 and 20 ampères, and the current for light between 4 and 15 volts, *without any jumps.* Cautery and light can be used simultaneously £4 0 0

Size: $9\frac{1}{8} \times 9\frac{1}{4} \times 2\frac{1}{2}$ inches.

(See footnote.)

To keep a platinum burner incandescent for a full hour, this apparatus consumes only about half a unit of electricity (price about 3d.).

No. 1681.	Similar transformer, for cautery only, or for light only ...	£3 0 0
No. 1685.	A. B. Woakes' transformer..	6 0 0

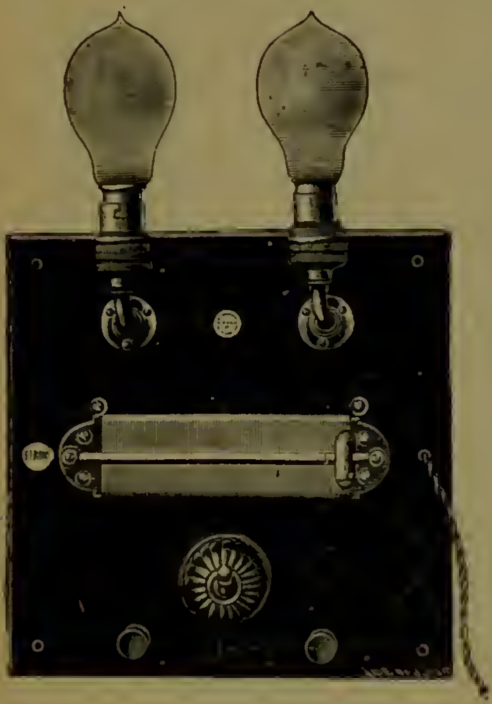
As supplied to :—

Drs. de Havilland Hall, E. Nettleship, M. Moullin, Sir F. Semon, S. Perkins, H. F. Waterhouse, R. J. Godlee, Knox Shaw, Wimpole Street; H. Butlin, W. Rose, E. Law, G. MacDonald, S. Edwards, S. Paget, T. Griffith, B. Dawson, F. Eve, R. Crocker, M. Morris, P. Jakins, F. Anderson, G. L. Cathcart, Watson Cheyne, C. A. Ballance, F. Burghard, H. F. Herring, C. E. Woakes, Walsham, Harley Street; S. Mackenzie, J. Hutchinson, V. Horsley, D. Maddock, Cavendish Square; Warner, Brechin Place; G. Schorstein, A. E. Bridger, Portland Place; B. Pollard, G. Herschell, C. Williams, E. Roughton, D. Wright, Queen Anne Street; G. Carpenter, S. Spicer, F. C. Wallis, Welbeck Street; P. Whitcombe, Earl's Court Road; W. R. Holmes, W. Powell, Burlington Street; S. Beauchamp, Cromwell Road; A. Allport, Milk Street; A. Routh, A. Bowlby, Manchester Square; T. Pringle, Seymour Street; Reg. Harrison, Lower Berkeley Street; A. Whitfield, Upper Berkeley Street; M. Jones, West End Lane; A. Cooper, Henrietta Street; C. Swan, Devonport Street; R. Owen, Devonshire Terrace; W. Kelson, Queen Street; H. White, Weymouth Street; Anderson, New Cavendish Street; Brow, Russell Square; Bourke, Moreton Gardens; Roxburgh, Bryanston Street; Wornum, Belsize Park; Lewis, Hamilton Terrace, etc., etc., London.

Drs. Thomas, Newport; Ridley, Palmer, Newcastle-on-Tyne; Pruen, Mouatt Biggs, Cheltenham; Claremont, Alexander, Southey, Robertson, Southsea; Groome, New Cross; Ross, Bournemouth; Cassidi, Derby; Cooke, Cambridge; Pearson, Cork; Murray, Johannesburg, etc.

King's College, Charing Cross, and St. Thomas's Hospitals; Infirmary, Leicester; Addenbrooke's Hospital, Cambridge; Throat Hospital, Great Portland Street; London Homœopathic and Westminster Hospitals; General Infirmary, Leeds; St. Peter's Hospital, Covent Garden, etc., etc.

CONTINUOUS OR ALTERNATING CURRENT SUPPLIES.



No. 1696.

No. 1695. Rheostat for utilising surgical lamps requiring between 4 volts and 20 volts from 100 volt supplies **£3 0 0**

As supplied to :—

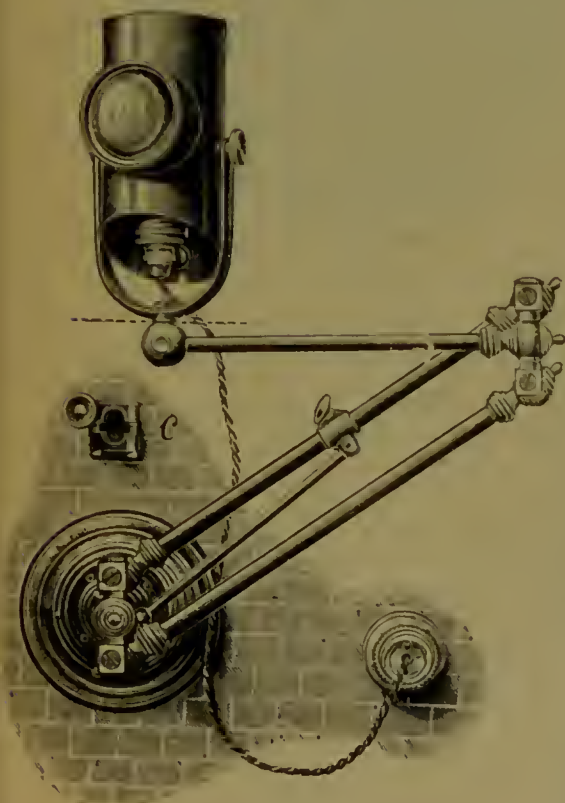
Milne Murray, Edinburgh; Hurry Fenwick, Savile Row, G. Makins, Charles Street, B. O'Connor, Arlington Street, London; M. Griegg, Dundee; New General Hospital, Birmingham; Royal Infirmary, Edinburgh; Queen's Hospital, Birmingham, etc., etc.

No. 1696. Similar rheostat, with 2 lamps, for 230 volt supplies, Fig. 1696 **£3 9 0**

No. 1698. Portable rheostat for surgical lamps, arranged in a polished mahogany case, $5\frac{1}{2} \times 11 \times 7$ inches **£4 0 0**

ILLUMINATING INSTRUMENTS.

To be used with the current supplied from dynamos.



No. 1710.

No. 1710. Dr. MacDonald's Lamp with bull's eye, for throat, nose, ear and eye examination, and for surgical and dental operations. The lamps are movable in all directions: they can be taken off the bracket to be used as hand lamps. Price, with parallel bracket, as shown in illustration, and with a 32-candle power *focus* lamp **£4 6 0**

As supplied to :—

Drs. Nettleship, W. Rose, V. Horsley, F. Semon, W. Roughton, S. Spicer, S. Lazarus, A. B. Rendel, P. Wornum, G. Wilkin, Ridge Jones, C. Cathcart, W. Anderson, L. Stevens, A. Warner, B. Howard, G. Carpenter, P. Wornum, Lennox Browne, W. Aiken, C. Stephen, F. Morison, London; Macintyre, Glasgow; Bickerton, Liverpool; Elliot, Chester; Ross, Bournemouth; Lodge, Bradford; Macleod, Sydenham; Gruenbaum, Permewan, Liverpool; Milligan, Bark, Manchester; Murray, Ridley, Newcastle; Dobic, Chester; Grubb, Ealing; Spain, Norwieh; Nicol, Leeds; Royston, Liverpool; Benthall, Derby; Irvine, Johannesburg, etc., etc.

Royal Victoria Hospital, Bournemouth; Addenbrooke's Hospital, Cambridge; Royal Infirmaries—Glasgow, Manchester and Aberdeen; New General Hospital, Birmingham; Manchester Ear Hospital; Infirmary, Halifax; Royal Free Hospital; Throat Hospital, Great Portland Street Queen's Hospital, Birmingham, etc., etc.

With an ordinary frosted lamp, the price would be 6/- less.

Focus lamps of other candle power can be supplied if desired.

No. 1712. The same lamp, without the bracket, but with a clamp (*C*), by means of which it can be easily fixed to any existing gas bracket £2 9 0

There is absolutely no trace of the filament visible *after the light has been reflected by the ordinary concave head mirrors.*

No. 1716.

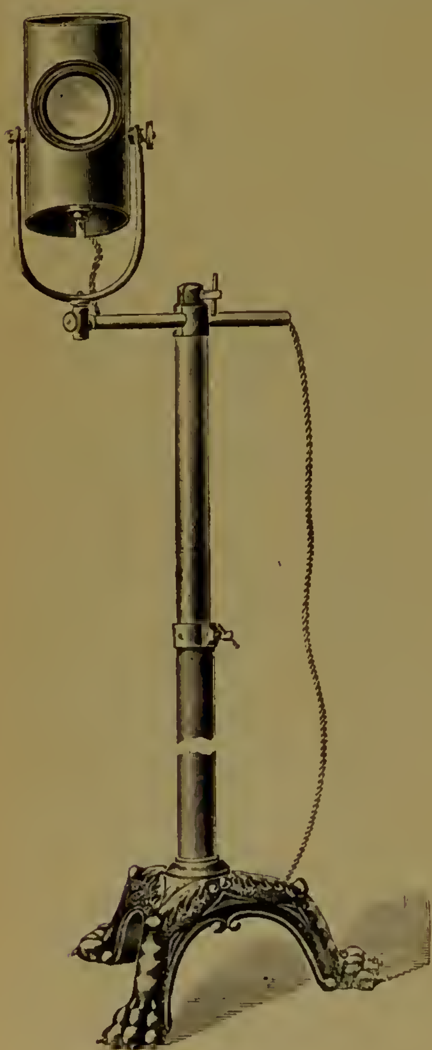
No. 1715. Dr. MacDonald's Lamp, on telescopic stand, total height 6 feet, with lens and focus lamp of 32-candle power, Fig. 1715 ... ...£4 0 0

No. 1716. Similar lamp, but on a stand suitable to be put on a table, Fig. 1716 ... 3 0 0

No. 1717. Edison Swan's Focus Lamps, of 32 or 50 candles, 100 volts 0 10 6

No. 1718. Ditto 200 volts 0 14 6

In ordering, please state the number of volts and candle power required.



No. 1715.

No. 1720.

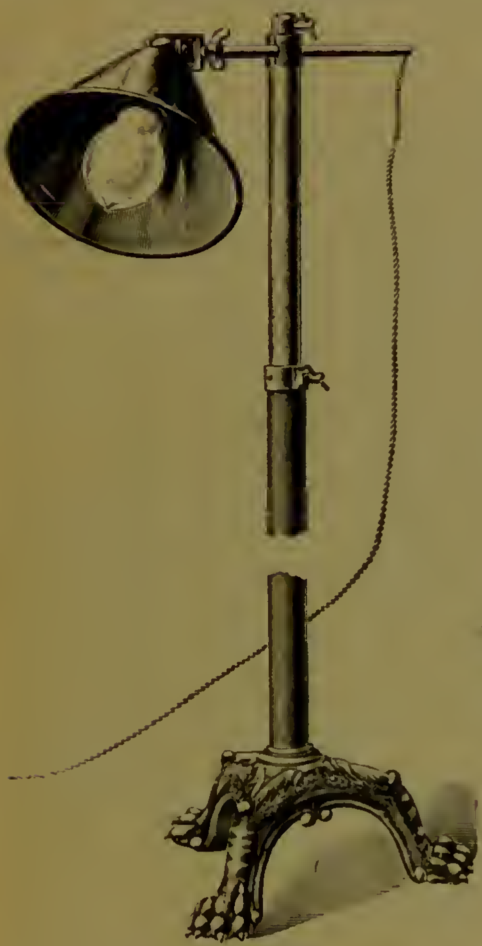
No. 1720. **Iris Diaphragm,** for utilising any of the above lamps, for **ophthalmoscopic** purposes, Fig. 1720 ... ...£1 1 0

As supplied to :—

Dr. Nettleship, Mr. Hutchinson, and Dr. Morrison, London; Dr. Bickerton, Liverpool; Dr. Claremont, Southsea; Royal Infirmary, Manchester; General Infirmary, Birmingham; Royal Infirmary, Aberdeen, and many others.

This can be added to any existing lamp, Figs. 1710 or 1715. The lens, which is held by a bayonet catch, is removed, and a frosted glass plate, bearing an Iris diaphragm, is inserted instead.

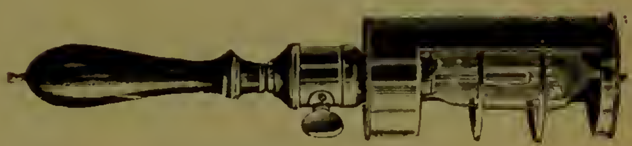
By means of this diaphragm the *intensity* of the light can be varied between ¼ and 20 candles, *without varying in any way the colour of the light*, which is all important for ophthalmoscopic purposes, and the frosted glass destroys any trace of the carbon filament.



No. 1726.

No. 1726. Stand with telescopic arrangement, total height 5 ft., with lamp and reflector, movable in all directions £3 3 0

This lamp may be used during operations, either for illuminating purposes, or for keeping exposed parts comfortably warm.



No. 1735.

No. 1735. Hand lamp, with reflector and switch ... £1 15 0

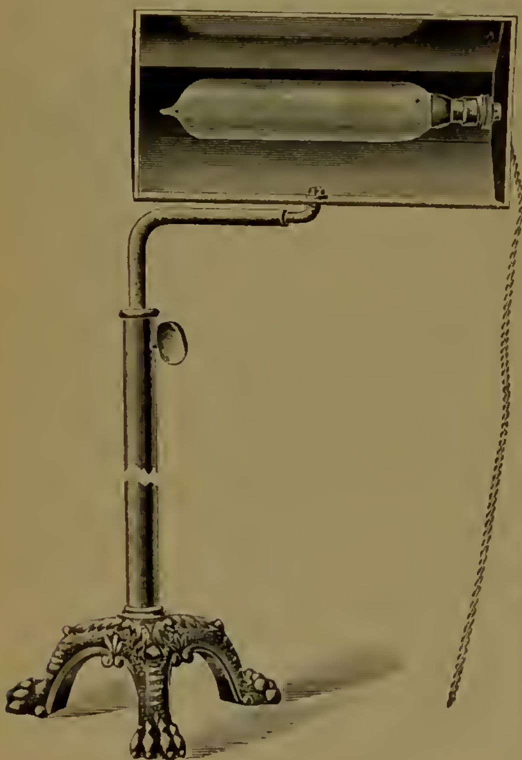
No. 1737. Similar lamp, with bull's-eye 3 15 0

ELECTRIC LIGHT AND HOT AIR BATH.

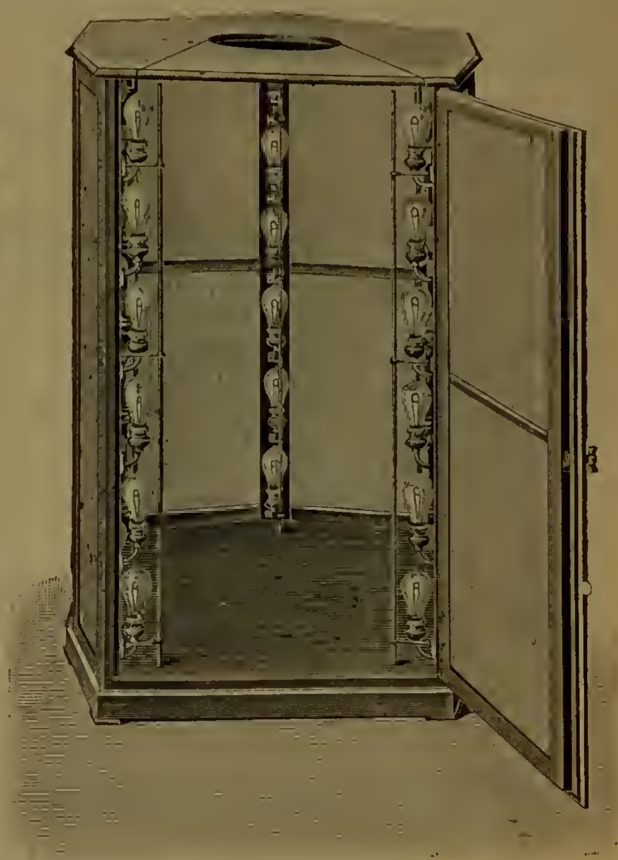
The good results obtained by sunlight bath have induced several doctors—Dr. Kellog, in Battle Creek, Michigan, seems to have been the first, in 1889—to try whether similar results could not be achieved with the electric light, in order to be independent of sunshine. The results were so favourable that many men took up this method, and for some time it has been used in this country, and the "Lancet" and "British Medical Journal" brought very favourable reports about this kind of treatment in cases of gouty and rheumatic affections, neuralgia, sciatica, obesity, asthma, etc.

A much higher temperature can be used in the electric hot air and light bath than in a Turkish vapour bath, partly because the perspiration of the body evaporates rapidly in the surrounding dry air, and this prevents a rising of the patient's temperature and produces a pleasant sensation, and partly because the head of the patient being outside the bath, he breathes air of ordinary temperature, and his lungs and heart do not become affected as in a Turkish vapour bath,

The regulation of the intensity of light and temperature is very simple in our apparatus, which can be used without further preparation wherever the electric light is available.

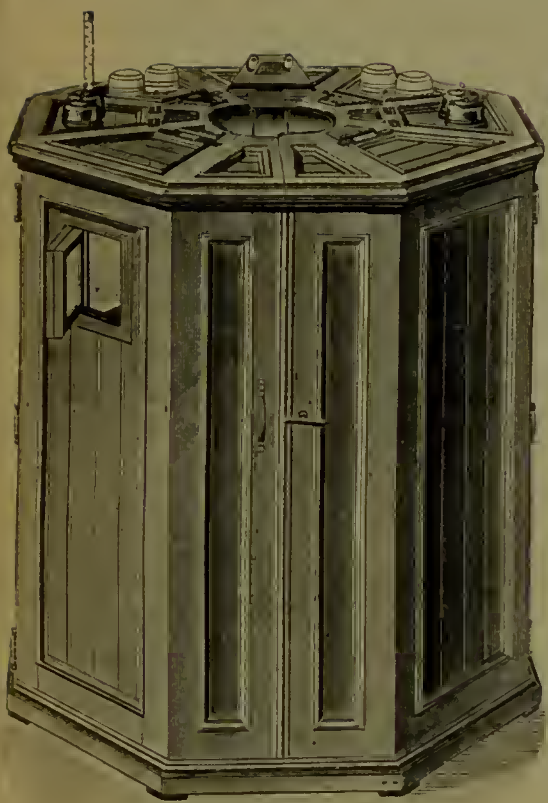


No. 1795.



No. 1798.

No. 1795.	Electric lamp for radiant heat, with reflector and stand for local applications while the patient is lying in bed, Fig. 1795	£3 10 0
No. 1798.	Plain electric light bath with 30 lamps, inside of cabinet is lined with mirrors, 2 switches, fuse, thermometer, etc., Fig. 1798	26 0 0

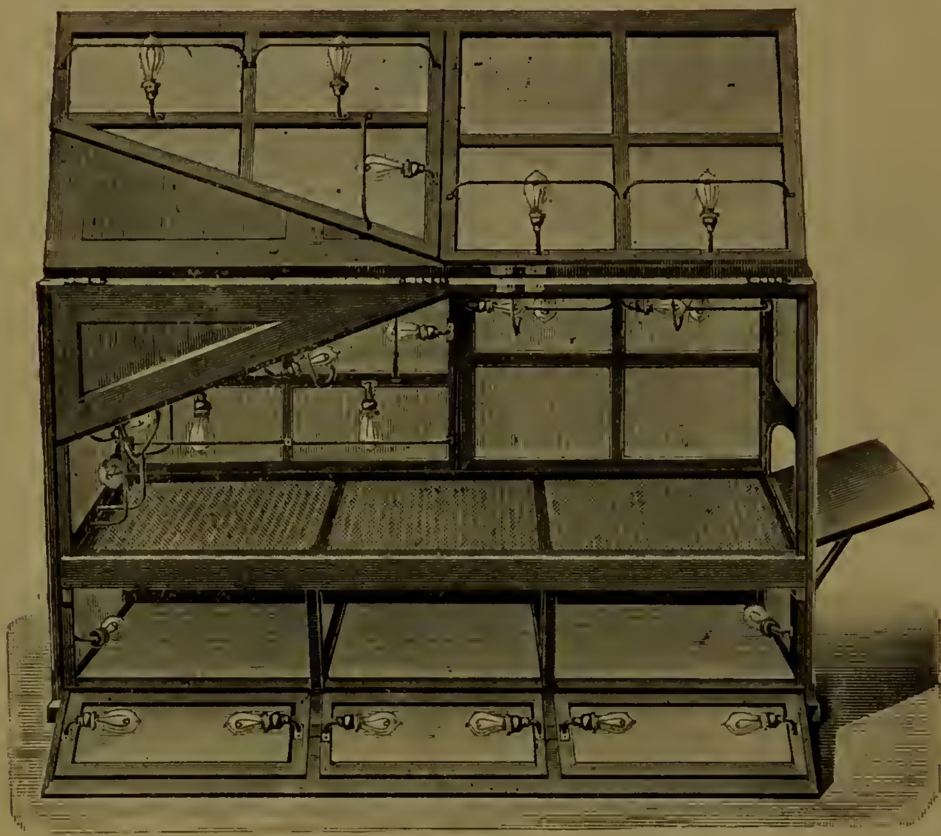


No. 1800.

No. 1800A.

No. 1800. Prof. Winternitz's apparatus with 48 lamps in sexagonal cupboard, with 2 doors. The walls inside are lined with mirrors. The patient sits on a seat made of glass rods. The lamps are switched on or off in groups of 8 at a time, and a thermometer indicates the temperature. The two illustrations show the apparatus closed and open. Price, complete £43 0 0

No. 1804. Similar apparatus, but with an arrangement to use either 24 incandescent lamps or 4 arc lamps... ... ... 60 0 0



No. 1808.

No. 1808. Light bath, with 36 lamps, to receive the patient in horizontal position, as shown in Fig. 1808 ... ... **£44 0 0**

Coloured lamps can be supplied instead of the white lamps, if desired.

Apparatus for local applications to arms or legs only are made to order. Photographs and estimates can be had on application.

No. 1840. Apparatus for applying locally currents of hot air (suggested by W. Taylor, M.D., Edin. See "Lancet," Nov. 26, 1898, page 1385) **£3 0 0**

This apparatus is made either to work with an 8-volt cautery battery or accumulator or from a cautery transformer or rheostat; or else it can be made so that it can be connected with a 100-volt supply and an incandescent lamp.

Fig. 1860 shows Professor Finsen's apparatus to treat lupus, etc., with an intense light. It consists of a powerful arc lamp of 10,000 candle-power, consuming a current of 55 volts and 80 ampères, one or several telescopes provided with lenses of rock crystal (diameter of the

No. 1860.

lenses 3 in.) to concentrate the light on a small spot, and with a water-cooling arrangement to prevent the heat rays from reaching the patient.

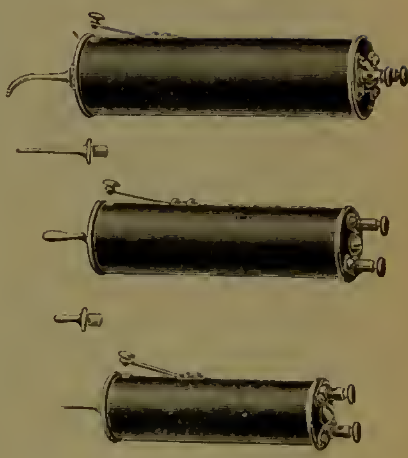
The price of the lamp, 4 telescopes suspended as shown in illustration, 4 loups with rock crystal lenses, dark spectacles, etc., amounts to about **£130.** If the E.M.F. of the current supplied does not exceed 110 volt, the lamp may be connected with a rheostat "in series" with such a supply, but if the E.M.F. is 200 volt or more, the waste would be too great and a motor transformer has to be used then, which increases the price of the installation by about **£160.** Estimates will be made after receipt of particulars about the E.M.F. of the available current.

VARIOUS INSTRUMENTS.

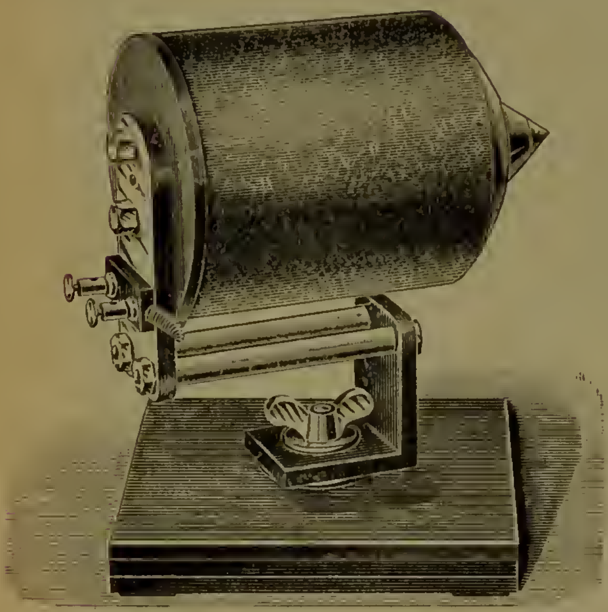
No. 2001.

No. 2001. **Invalid's Bell,** complete with large dry cell, 3-inch bell, 12 yards of flexible cord, and push £0 18 0

No. 2002. **Electro-magnet,** with 5 different points, for removing pieces of iron or steel from the eye £1 10 0



No. 2002.



No. 2005.

No. 2005. Large **Electro-magnet,** to be connected with 100 or 200 volt continuous currents from dynamos ... £6 0 0

No. 2007. Prof. Haab's Double Pole **Magnet** with table, for 100 volts, with rheostat 27 0 0

(Illustration can be had on application.)

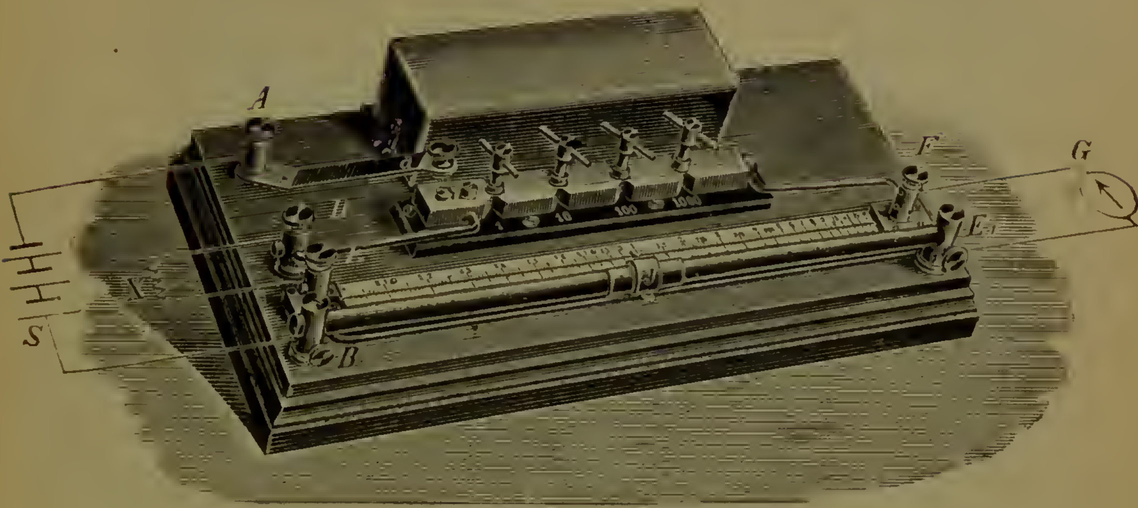
No. 2008. Similar **Magnet,** for 230 volt supplies £32 0 0

No. 2018.

No. 2018. **Bullet Finder** £0 9 6

In a narrow metal tube two needles are fixed, insulated from each other, their points reaching beyond the end of the tube. The apparatus, when connected up with one cell and a galvanometer or electric bell, will deflect the galvanometer or ring the bell immediately both points are brought into contact with a metallic body.

No. 2020. **Wheatstone's** Universal Measuring Bridge, after Prof. Kohlrausch, with resistances of 1, 10, 100 and 1,000 ohms, and bridge wire, Fig. 2020 ... ... £6 10 0

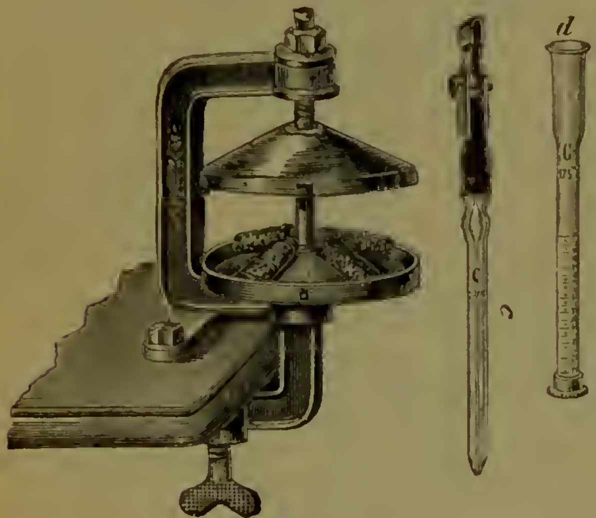


No. 2020.

This bridge is especially arranged for quick measurements with direct reading of the resistances of the human body, etc., and is accurate for resistances between about 2 ohms and 10,000 ohms. For measuring the resistance of fluids it is best to use the alternating current and a telephone (price 17/-); for measuring the resistance of solid bodies, the continuous current, with galvonometer Nos. 277 or 278, had better be used.

The bridge is used by Drs. Althaus, Gamgee, Milne Murray, Stone, Turner; Guy's Hospital, etc.

No. 2025. **Centrifugal Machine,** for examining blood, urine, milk, etc., with 12 testing tubes, and case containing pipette, burette, &c., suggested by Prof. Gaertner **£3 0 0**



As supplied to Charing Cross Hospital, Westminster Hospital, North - Eastern Hospital for Children, Dr. Keser, St. George's Hospital, Owen's College (Manchester), Dr. M. Murray, Dr. Keightley, Mr. Fenwick, Royal Infirmary, Liverpool, etc., etc.

No. 2025.

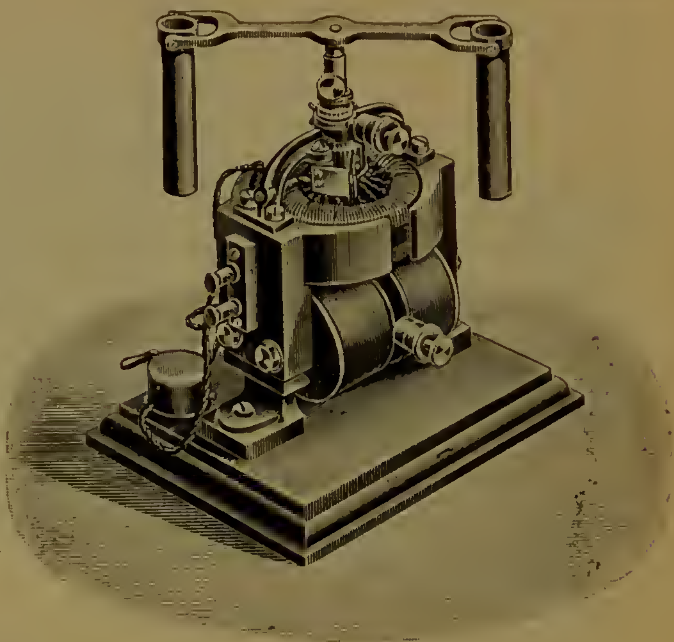
By means of this apparatus, the red parts of a drop of blood can easily be separated from the serum within a few minutes, and the exact proportion can be read on a scale in %. The sediments of urine, etc., are also obtained within a few minutes, and the chemical analysis can be begun at once; this is of great importance in some cases of disease, and in hot climates. Printed instructions for examining blood, etc., are sent with the apparatus.

The instrument is simpler than any other centrifugal machine. There is no need to drive it by hand all the time. It is started like a spinning top, by the pulling of a cord, and the machines are so well made that they keep rotating for some ten minutes.

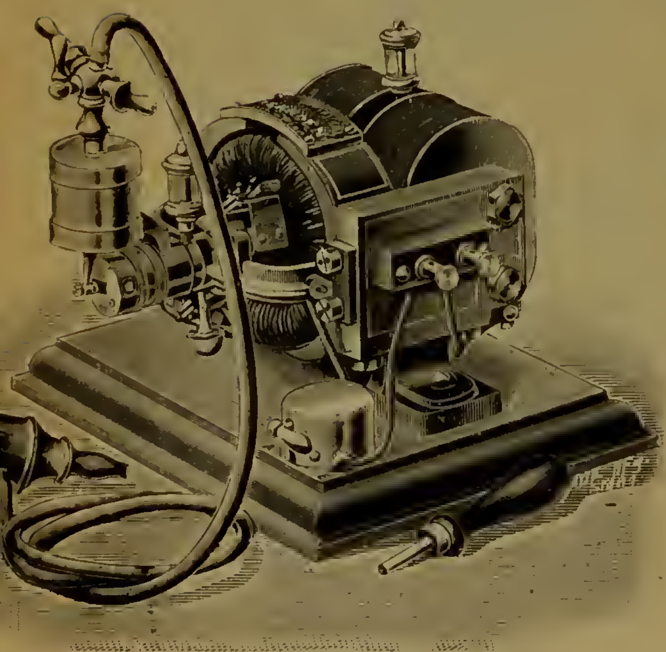
No. 2027. **Centrifugal Machine**, connected with an electric motor. The motor can be arranged either for a 10-volt current from a battery, or the 100 or 200-volt currents from dynamos (continuous or alternating currents).

£6 10 0

In ordering, please state the source of electricity with which it is to be used.



No. 2027.



No. 2030.

No. 2032.

No. 2030. Electric motor for **pneumatic massage of the ear.** The pump attached to the motor compresses and evacuates the air alternately, once with every revolution of the armature, Fig. 2030 ... ... £8 10 0

As supplied to Drs. Law, Greville MacDonald, etc., etc.

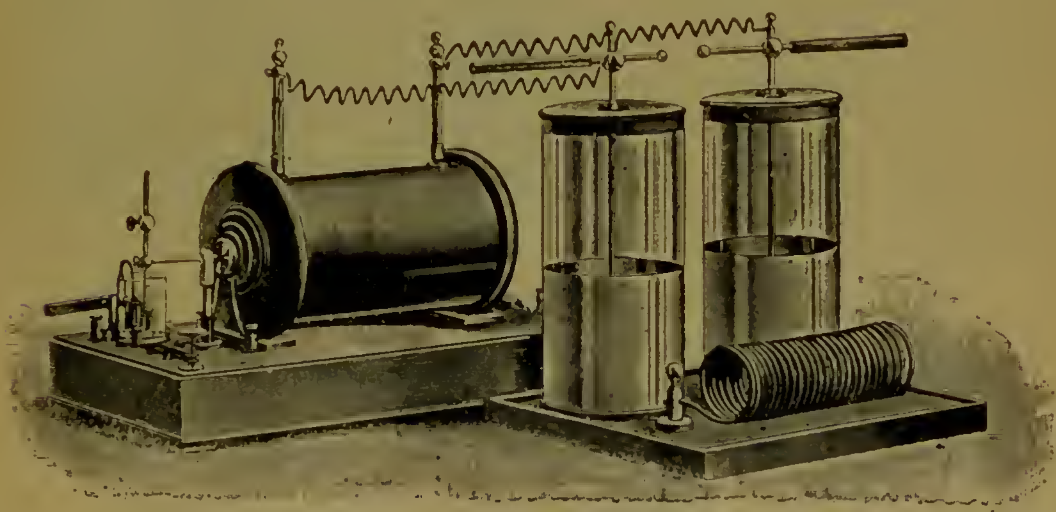
No. 2032. Similar pump, but the electrical motor is replaced by a flywheel to be driven by the hand 4 16 0

No. 2040.

No. 2040. **Apparatus for generating ozone,** complete ... **£5 10 0**

(To work the coil a 2 to 6-cell battery is required; accumulators, large bichromate cells, or very large dry cells will do.)

No. 2043. **Tube for generating ozone** (to be connected with any spark coil used for Röntgen Photography)... ... **£1 5 0**



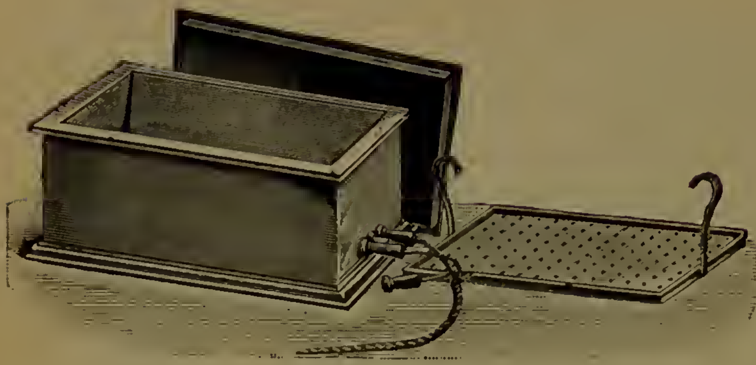
No. 2050.

D'Arsonval's apparatus for producing high frequency currents.

The spark coils used for Röntgen photographs can be used for this apparatus, too.

No. 2050. D'Arsonval transformer, with 2 large Leyden jars, etc., as shown in Fig. 2050 (price does not include the spark coil) **£5 10 0**

No. 2055. D'Arsonval's solenoid to enclose patient in horizontal or vertical position (photograph on application) **£9** to **£16 0 0**



Water Kettle, to be connected with a 100 or 200 volt supply, for sterilizing instruments, Fig. 2071.

No. 2071.

No. 2070	Size 8 × 4 × 4 inches	£3	15	0
No. 2071.	,, 12 × 8 × 4 ,, ...	6	10	0
No. 2072.	,, 20 × 8 × 4 ,, ...	9	10	0

With 100 volt, 4 ampères are consumed by these kettles.
,, 200 ,, 2 ,, ,, ,, ,,

No. 1890. **Javal Schioetz Ophthalmometer,** with improved transparent figure plates (as supplied to Moorfields Hospital) **£18 0 0**

In the old instruments, the light is *reflected* from *enamelled* plates, but in this new instrument, candles or electric lamps are placed *behind transparent* plates. This is a great improvement, and the images on the patient's eye are more distinct and clear.

No. 1892. Iron Table for the above apparatus **£1 12 0**

No. 1890.

No. 1897.

No. 1897. **Laryngo-Stroboscope** ... **£5 15 0**

This instrument has been constructed to make it possible to see the single vibrations of the vocal cords. The sirene fixed on the head-band has to be worked by an electric motor.

CONTENTS OF THE PRICE LIST.